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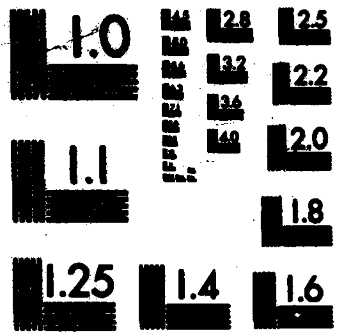

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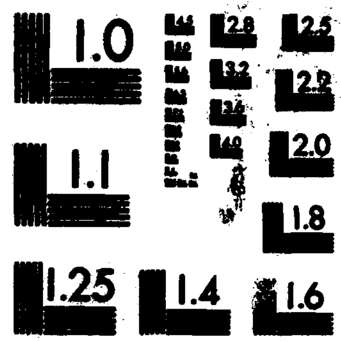

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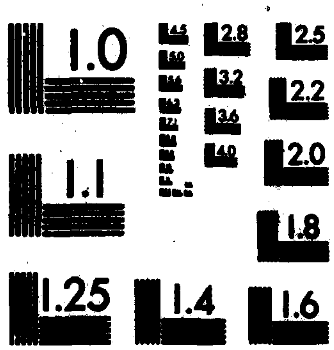

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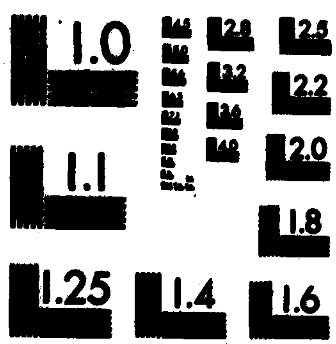

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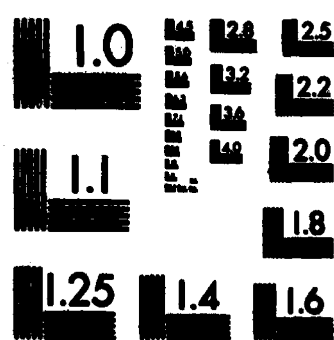

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LEVEL II

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AD A120856

DESIGN HANDBOOK STUDY FOR DRONE/RPV ACQUISITION AND MODIFICATION PROGRAMS

February 1974

Prepared for

AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
Wright-Patterson Air Force Base, Ohio

Under Contract F33657-73-A-0034-0005

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ABSTRACT

Background information for the development of a design handbook for drone/RPV (remotely piloted vehicle) procurements is presented. The feasibility of developing such a handbook is affirmed. A proposed handbook outline is developed, along with procedures for handbook use, listings of specifications and standards to be examined for inclusion, and limitations of handbook data for contractual purposes. In addition, the Air Force procurement process is analyzed for relative cost impact of the various decision points involved in drone/RPV acquisitions.

SUMMARY

The objectives of this study were to determine the feasibility of a drone/RPV design handbook and to develop background information relating thereto. An extensive data base has been assembled, consisting of applicable DoD regulations and manuals, related military specifications and standards, and similar design handbooks for other systems. Pertinent comments and recommendations have been obtained from a large group of Air Force and industry representatives. Limitations on the contractual use of a design handbook due to the ASPRs and other regulations were investigated. Conclusions and recommendations reached as a result of the study are summarized below.

CONCLUSIONS

a. A drone/RPV design handbook is a feasible and worthwhile enterprise. The handbook could be used to procure drone/RPV aircraft adequate for the stated mission requirements without costly overdesign, testing, or reporting; and to reduce design changes caused by the application of inappropriate specifications and standards.

b. The design handbook should contain extracts and modifications of drone/RPV-related specifications and standards, and also newly generated specification material tailored for drone/RPV use. The handbook format and contents should provide sufficient guidance to the drone/RPV military program managers so that they might implement timely procurement action in an efficient, cost-effective manner. Contractors will be given explicit guidance, and unnecessary high-cost testing and documentation requirements will be eliminated.

c. A design handbook will not substitute for the sound judgment and expertise of the assigned program manager, but will provide him valuable assistance in his tasks – particularly in the time-consuming area of making routine decisions. The design handbook format and organization should enable the manager to write a contract describing the desired drone/RPV configuration, and detailing the contractor's obligations in a timely and efficient

manner. Risks incident to tradeoffs of design or data-item requirements versus cost should be noted.

d. The design handbook cannot legally replace the contractual use of certain military specifications and standards. The handbook should describe these and provide reference to the controlling regulations.

e. Keeping the handbook updated and current will be essential. Evolving technology and new drone/RPV types will necessitate continuing changes. As the underlying military specifications and standards are modified or new ones issued, handbook sections will have to be changed as appropriate. Changes will also be generated as experience is gained in the use of the handbook and the need for improvement is recognized.

RECOMMENDATIONS

It is recommended that a design handbook for drone/RPV acquisition and modification be prepared, to incorporate extractions and modifications of pertinent top-level specifications and standards, to offer cost-saving suggestions to the using program manager and project engineers, and to detail the most effective methods for the acquisition/modification processes.

It is further recommended that the design handbook format follow the general outline developed in Section 2 herein, and to take into consideration the practices and philosophies noted in this investigation and discussed in subsequent sections of this report.

CONTENTS

TABLES

1 INTRODUCTION

1.1 SCOPE OF STUDY

ARINC Research Corporation has been contracted by Aeronautical Systems Division, Air Force Systems Command, to determine the feasibility of developing a design handbook for drone/RPV acquisition and modification programs, and to develop a body of background data sufficient to establish a firm basis for generating the document. The handbook is to contain specifications and standards specifically tailored to drone/RPV programs, and reflect the associated realities of low cost and limited life cycle.

The Corporation was directed to give specific attention to the Drone Control and Data Retrieval System (DCDRS) program specification requirements to assure that the upcoming Phase II of that program will receive maximum benefit from this effort.

Subtasks of the overall study included:

a. An evaluation of the effectiveness of specifications and standards applied to the DCDRS and AQM-34 series drone programs, through a review of historical data and interviews with Air Force and industry personnel.

b. A review of current DoD specifications and standards for applicability to existing, planned, and future drone/RPV programs. Standards and specifications concerning hardware (airframe, engine, avionics, and command and control) and other factors (reliability, maintainability, quality assurance, safety and parts standardization) were to be examined.

c. Discussions and meetings with industry representatives to determine the best means of obtaining drone/RPV quality and performance at the lowest possible price.

d. An evaluation of how specifications and standards can best be applied to specific types of drone/RPV programs, e.g., competitive prototype development, feasibility demonstration, Class V modification, and preproduction and production programs.

e. An analysis of how Air Force procurement policies, to the extent that they reference existing standards and specifications, would be affected by changes to existing specifications.

Results of the investigation are presented in this report. Included herein are all analyses and evaluations necessary to document the study effort and to permit objective evaluation of the resulting conclusions; and specific recommendations for the format and content of the design handbook.

1.2 BACKGROUND

The history of drone usage in the Air Force has been characterized by a wide spectrum of procurement approaches. At the two extremes are the AQM-91A, which was procured against a demanding specification for both performance and quality; and the AQM-34 series, which was an outgrowth of a quick-reaction activity using a target drone as a base and having little or no military-specification obligations at the outset. Specification requirements of other drone programs have fallen somewhere between these extremes.

Even in some programs where performance specifications were apparently imposed properly, unrealistic tests were conducted and unnecessary data demanded on the basis of man-rated military specification wording. Conversely, where requirements have not been explicit, misunderstandings between contractor and Air Force representatives have sometimes caused costly delays and redesigns.

The Department of Defense is understandably concerned about the application of unreasonable contract requirements, which increase procurement costs. For drone/RPV procurements in particular, many of the military specifications are inappropriate, having been written to describe either manned aircraft or missiles. Drone/RPV designs generally fall in an area where man-rating can be removed, testing reduced, and load factors relaxed, but where mission survivability remains a critical factor.

The problems inherent to the ambiguous application of military specifications were addressed in a recent paper.* Although the example chosen for that discussion pertains to communications equipment, the surrounding circumstances are meaningful to drone development programs. The example taken was a comparison of the number of specifications applied to a military UHF transceiver versus the number applied to a commercial, functionally similar VHF transceiver. For the commercial equipment, only nine documents were needed to totally describe the needed requirements. For the military equipment, 44 documents were directly referenced (22 specifications, 17 standards, 5 publications); and one of the specifications (MIL-E-5400) referenced 408 specifications and standards through the next tier alone. This was doubtless a major reason that the commercial transceiver cost only a sixth as much as the military equipment performing the same basic function.

The Air Force has faced many such problems of its own. That, together with the design-to-cost philosophy being stressed by DoD and the continuing necessity to obtain required capabilities within usually austere budgets, has encouraged the Air Force to seek new and better ways to assist its program managers in the efficient development and acquisition of drone/RPV systems. An obvious first step was the necessity of clarifying the ambiguous situation concerning the applicability of design and performance specifications – which specifications are actually needed, and to what extent is each applicable? The Air Force concluded that a design handbook containing specifications and standards specifically tailored to drone/RPV programs would be highly beneficial, and subsequently contracted ARINC Research to determine the feasibility of and to lay the groundwork for developing such a document.

1.3 OVERALL STUDY APPROACH

The initial activity in this study was a review of various drone programs and the DCDRS effort. Detail specifications and documentation relating to the AQM-34 series vehicles, DCDRS, Compass Bright, and other similar programs were reviewed to determine which military specifications and standards were referenced. Additionally, Air Force and industry personnel were interviewed and their comments solicited concerning the use (and misuse) of specifications and standards. The questionnaire they were asked to complete is reproduced in Appendix C. Appendixes A and B list the documentation reviewed and personnel interviewed.

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*Wilson, M. F., "Designing to Price for the Commercial Market and Its Applicability to the DoD," Collins Radio Company paper dated February 13, 1973.

Also reviewed were ASPRs and Air Force and subsidiary-command regulations and manuals to note their references to military specifications and standards. These references were analyzed and then used, along with comments from cognizant Air Force personnel, to evaluate the effect on Air Force procurement policy of changes to existing specifications by tailoring them to drone/RPV design. Conversely, the impact of Air Force procurement policy on the design, format, and utility of a drone/RPV design handbook was considered.

1.4 FINAL REPORT

The end-product of the study was the recommended outline of a drone/RPV design handbook, which is presented in Section 2 of this report. Subsequent sections discuss the results of the activities that led to the formulation of the handbook outline, and of other tasks conducted in conjunction with the handbook effort.

2 ORGANIZATION OF DRONE/RPV DESIGN HANDBOOK

This section presents a proposed outline for a drone/RPV design handbook, subject to any modification deemed desirable while the handbook is being developed. That qualification will be implicit in the following discussion.

The handbook will be divided into six sections:

1. Introduction
2. System Definition
3. Design Specifications
4. Production Specifications
5. DD Form 1423 Data Requirements
6. Design Checklist

Included will be guidance to the program manager in the proper use of the handbook, a generalized work breakdown structure relating to drone vehicles, and a complete statement of specifications and standards suitable for drone/RPV procurement. An appendix will provide the framework for drafting a drone/RPV detail specification.

2.1 HANDBOOK OUTLINE

The proposed outline for the drone/RPV design handbook is broken into the following major subsections. The objectives of each section are briefly noted.

1. <u>Introduction</u>

   1.1 <u>Intent of Handbook</u>

   This subsection will state the intent of the handbook, which is to:

   a. Provide guidelines for minimizing the cost of ownership for an acceptable mission capability.

   b. Provide a self-contained specification reference for drone/RPV system procurement.

c. Permit the program manager flexibility consistent with realistic product reliability, performance, and quality requirements.

d. Prevent the costly generation of data and analyses where not justified.

e. Permit the application of proven contractor techniques, design practices, components, and tests where cost savings are clear.

1.2 Authority and Obligation

This subsection will:

a. Present a disclaimer stating that in the event of any conflict between its contents and existing regulations (Air Force or DoD), the latter shall govern.

b. Explain that variations from the requirements contained therein must be justified on the basis of life-cycle cost, time-urgency, or existing DoD regulations.

c. Direct the program manager to certain regulations which require direct application of military specifications or standards.

1.3 Scope

This subsection will state the scope of the design handbook, i.e.:

a. Military specifications and standards are not to be considered unless specifically identified in the handbook.

b. The handbook is not concerned with functional performance specifications, nor with management techniques.

2. System Definition

This section will describe the details of the procurement procedure for drone acquisition and modification programs, and assist the program manager in the proper use of the handbook.

2.1 Phase Description

This subsection will describe the acquisition process in terms of its constituent phases (e.g., contract definition, engineering development, etc.). Such identification will be required for utilization of the specification-application matrix of Subsection 2.3.

2.2 Functional Description

This subsection will present a generalized work breakdown structure (WBS) of a total drone/RPV system, including the controller, launch and recovery subsystem, payload/weapon, etc., and will be outlined in a system relationship. With the WBS, the program manager can identify his system as a coded subset useful in standardizing contractor responses, and in applying the program matrix of Section 2.3.

2.3 Program Matrix

This section will contain a matrix with program/system descriptors (e.g., speed, altitude) along one axis and applicable specification areas (e.g., environmental) along the other. Matrix intersections will be the applicable handbook paragraph numbers.

3. Design Specifications

This section will address specification requirements applicable to the design process. It will be divided into "general" and "detailed" categories as discussed below.

3.1 General Specifications

These specification requirements are applicable across-the-board or at the system level. Some examples are:

a. Reliability/maintainability allocation, prediction, and testing
b. Human engineering
c. Environmental conditions
d. System safety
e. Quality assurance

3.2 Detail Specifications

Detail specifications are peculiar to components of an RPV system. They reflect component conditions and usages that are sufficiently different from the general case that cost savings or performance improvement can be realized if treated as a special case. In cases of apparent conflict with general specifications, the detail specification will take precedence. Detailed specifications will be coded by the WBS element to which they relate.

4. Production Specifications

Production specifications pertain to manufacturing processes, materials, and criteria applicable to the contract item (CI) and to its acceptability as a deliverable to the Air Force. As for the design specifications, the production specifications will be broken into:

4.1 General Specifications

4.2 Detail Specifications

5. DD-1423 Data Requirements

This section will provide a subset of those contract data requirements contained in AFR-310-1* judged to be applicable to the spectrum of procurements defined for RPV's in the design handbook. With specific exceptions, the required data will probably be acceptable in contractor format (depending on contractor experience), provided that certain basic elements are included. Specific paragraphs or items from this section will be referenced in the matrix of Section 2.3.

5.1 Periodic Data Requirements

Periodic data requirements will include status reporting of technical cost and production progress.

5.2 One-Time Data Requirements

One-time data requirements will include program plans, analyses, lists, drawings, and other data as necessary.

*Air Force Regulation 310-1, Management of Contractor Data

6. Design/Procurement Checklist

This section will present a checklist of those items relating to drone/RPV design and procurement that the program manager or system designer should consider.

Handbook Appendix

In an appendix to the design handbook, the framework of a drone/RPV development specification will be generated. This specification will be based on the MIL-STD-490, Type B1 (prime-item development specification requirements). A rough outline of the specification is shown below (taken from MIL-STD-490, Appendix II). This development specification framework will permit the program manager to draft a detail specification properly and quickly by completing details relating to his particular program through use of the handbook utilization matrix, checklist, and other appropriate handbook sections.

1. Scope
2. Applicable Documents
3. Requirements
   - 3.1 Item definition
   - 3.2 Characteristics
   - 3.3 Design and construction
   - 3.4 Documentation
   - 3.5 Logistics
   - 3.6 Personnel and training
   - 3.7 Major component characteristics
   - 3.8 Precedence
4. Quality Assurance Provisions
   - 4.1 General
   - 4.2 Quality conformance inspections
5. Preparation for Delivery

2.2 SPECIFICATION CONVERSION TO HANDBOOK FORMAT

The main effort involved in writing the handbook will be in extracting and modifying portions of existing military standards and specifications to make them applicable to drone/RPV procurement. Figure 2-1 illustrates how the conversion may be accomplished and the resulting handbook entry.

MIL-STD-454C

REQUIREMENT 35

RELIABILITY

1. Purpose. The purpose of this requirement is to direct the implementation of reliability principles and techniques in the design and development of electronic equipment.

2. Document applicable to Requirement 35:

MIL-STD-785 Requirements for Reliability Program (for Systems and Equipments)

3. Quantitative reliability. Quantitative reliability requirements shall be as specified in the contract or in the end item system/equipment specification.

4. Reliability program. The contractor shall establish, maintain, and document a reliability program in accordance with the guidelines of MIL-STD-785, incorporating those tasks and requirements specified in the end item system/*equipment specification or statement of work.*

HANDBOOK

Reliability

1. Purpose — The purpose of this requirement is to direct the implementation of reliability principles and techniques in the design and development of a drone/RPV.

2. Quantitative reliability and confidence levels of the vehicle shall be as specified for the following operational aspects:

   1) Checkout Reliability — Checkout reliability of the vehicle shall be not less than ____ percent. Checkout reliability means the probability (numerically expressed) that any vehicle selected at random will pass all prescribed checkouts required to prepare the vehicle for launch

Figure 2-1. Example of Specification to Handbook Conversion Process

3
UTILIZATION OF DESIGN HANDBOOK

There are often conflicting pressures concerning the extent to which military standards and specifications are actually applied in a given program. On the one hand is the pressure of responsibility on those ultimately responsible for the success of the program – they want the proper specifications fully applied. On the other hand are the real-world pressures of time (there never seems to be enough to do everything just right), and funds (the rigid application of specifications could impose cost burdens in excess of available funds). A drone/RPV design handbook would help to alleviate this problem by drawing upon the experiences of those who have managed to cope with it in a satisfactory manner. The means would be a suitable set of specifications and standards for a given program, with some flexibility of application as dictated by circumstances.

During the preprocurement period, many decisions are weighed that involve risk and cost tradeoffs. The availability at this time of a handbook focusing past experience into a condensed and logical form could be extremely helpful in guiding the persons charged with these decisions. Most of these decisions can be made automatically by use of the handbook, dependent only upon the key factors or descriptors peculiar to each program.

3.1 INITIAL INTENT

Ideally, the drone/RPV design handbook would provide Air Force program managers and their personnel with a single-source document to guide the writing of a drone/RPV program specification. During the course of this investigation, some doubts have been cast on the achievement of this ideal because of the governing nature of various DoD regulations in calling out specifications and standards (see Section 9). This obstacle could be overcome by implementing a sufficient authorization level for the handbook.

As of the conclusion of this study, it appears that the practical route to attaining the single-source handbook document is an interim phase wherein a hybrid combination of new specification material (where none now exists) is combined with a reference index to specific paragraphs of existing specifications, and suitable modifications to these paragraphs. The reference paragraphs appropriate for a given program would be shown in a matrix, relating system and program descriptors to applicable specification paragraphs.

3.2 HANDBOOK APPLICATION

Although a design handbook is associated primarily with the prime-contract procurement package, its system definition material would be useful in earlier stages. For example, the process of writing the program management directive (PMD) would be aided by recognizing and understanding the scope of the system to be procured in sufficient clarity to highlight the required support systems and the major cost and performance tradeoffs. Such a consideration might, in fact, reveal that additional analysis is necessary prior to a firm definition of a cost-effective system. In Section 7 of this report, the impact of an early system-definition study on life cycle cost and performance is discussed.

During the precontract period, and given that a PMD has been generated, the program manager would concentrate his earliest efforts on system definition (required by Section 2 of the proposed handbook). Basic considerations such as the boundaries between government- and contractor-furnished equipment, and interfaces between prime and support equipment, would be identified by use of the work breakdown structure carried out to at least the major equipment level. The WBS can also be used to support the identification of risk areas and an evaluation of the approach taken by the program manager to minimize the possible consequences of significant risks.

3.3 SELECTION OF SPECIFICATION DATA

When the drone/RPV system has been sufficiently defined, the program manager must then select the descriptors which best fit his system and procurement requirements. A typical list would be:

a. Vehicle characteristics

- Speed
- Attitude
- Payload type
- Recovery method
- Launch method
- Flight duration

b. Intended operational environment
c. Mission reliability/survivability
d. Operational and logistic support
e. Cost factors
f. Mission versatility
g. Type of procurement
h. Storage concept
i. Production quantity

Variations of the entries in the above list would yield a large number of possible combinations of program types. Certain of these combinations have significance relative to the family of specification-type provisions to be included in the procurement. The matrix of Table 3-1 is a preliminary ordering of these combinations to correspond to specification provisions in a way that simplifies the program manager's task. This matrix will be an important part of the drone/RPV design handbook (see Section 2.3). Upon selecting the appropriate descriptors, the handbook user refers to the matrix and is guided to a unique set of specification provisions that he may review if desired. Subject to changes occasioned by his review, the program manager may then, with one general statement, impose the indicated set of provisions upon the contractor through the procurement package, calling out any necessary changes by specific exception.

In the preliminary matrix, the left-hand column contains the basic system and program descriptors. System descriptors include functional and operational features of the system and the environment in which it will operate. Program descriptors are such procurement factors as production quantity and type of contract. These two types of descriptor are grouped separately in the matrix. Each descriptor is given a range of values, in some cases quantitative, representative of a meaningful categorization within the scope of the descriptor. Selection of one category, or more if appropriate, from each descriptor is tantamount to defining the planned system and program for the purposes of specification application.

Across the top of the matrix are the various specification categories. These categories are listed in a left-to-right order corresponding to their occurrence in the handbook outline given in Section 2 of this report. The categories are arranged in three groups: general specification areas, detailed specification areas, and DD-1423

TABLE 3-1. MATRIX OF PROGRAM/SYSTEM DESCRIPTORS AND APPLICABLE SPECIFICATION PARAGRAPHS

Program/System Descriptor		General Specification Area							Detailed Specification Area						DD-1423 Data Items (Contractor Format Unless Keyed to AF-310)					
		Envir.	Qual.	R&M	ILS	EMC	Safety	(Etc.)	Air Veh.	Eqpt.	GC Sta.	Relay	Data	(Etc.)	Status Rpts	Plans	Test Rpts	Dwgs	Parts Lists	(Etc.)
Speed (Max)	<M 0.95	X							X	X										
	>M 0.95	Y							Y	Y										
Altitude (Max)	<20,000 ft (MSL)	X							X	X										
	>20,000 ft (MSL)	Y							Y	Y										
Prob. of Survival (Operational)	<0.5		X	X	X				X	X		X								
	>0.5 to <0.95		Y	Y	Y				Y	Y		Y								
	>0.95		Z	Z	Z				Z	Z		Z								
Geographic Application	Over Water	X					X		X											
	Over Land (Friendly)	Y					Y		Y											
	Over Land (Enemy)	Y					Z		Z											
Prime Mission Equipment	Weapons	X		X		X	X		X		X	X	X							
	Optical	Y		X			Y		Y		Y	Y	Y							
	RF Sensor	Z		X		Y	Y		Z		Z	Z	Z							
	RF Radiator	Z		X		Z	Z		A											
Launch	Zero-Length Launch	X					X		X											
	Rail/Catapult Launch	Y					X		Y											
	Air Launch	Z					Y		Z											
Recovery	Chutes: Air	X					X		X											
	Chutes: Ground	Y					Y		Y											
	Chutes: Water	Z					Y		Z											
	Controlled: Air	A					Z		A											
	Controlled: Ground	B					A		B											
Flight Duration	0 – 1.5 hr	X		X								X								
	1.5 – 10 hr	Y		Y								Y								
	>10 hr	Z		Z								Z								
Operational Support Concept	Strictly Air Force				X				X		X		X							
	Comb. Air Force/Contr.				Y				Y		Y		Y							
	Total Contractor				Z				Z		Z		Z							
Logistic Support Concept	Largely AF Depot				X				X	X									X	
	Largely Contr. Depot				Y				Y	Y									Y	
	Combination				Z				Z	Z									Z	
Payload Cost	< 20% of Air Vehicle		X	X																
	> 20%, < 50% of Air Vehicle		Y	Y																
	>50% of Air Vehicle		Z	Z																
Other Future Applications	Unlikely		X	X	X												X	X		
	Probable		Y	Y	Y				X		X		X				Y	Y		
	Already Defined		Z	Z	Z				Y		Y		Y				Z	Z		
Procurement Type	QRC						X		X	X	Z		Z		X		X		X	
	Mod. of Existing Res.						Y		Y	Y					Y	X	Y	X	Y	
	Competitive New System						Z		Z	Z					Z	Y	Z	Y	Y	
Acquisition Phase	Contract Definition				X				X	X	X	X	X		X	X				
	Engineering Development	X	X	X	Y	X	X		Y	Y	Y	Y	Y		Y	Y	X	X	X	
	Production	Y	Y		Z										Z		Y			
Potential Production Quantity	1 – 10 Units		X	X	X		X		X	X	X		X							
	10 – 100 Units		Y	Y	Y		Y		Y	Y	Y		Y							
	>100 Units		Z	Z	Z		Z		Z	Z	Z		Z							
Storage Concept	Controlled Full-Up				X				X	X										
	Uncontrolled Full-Up				Y				Y	Y										
	Controlled Disassembly				Z				Z	Z										

NOTE: Symbols are used arbitrarily here to represent paragraph numbers of applicable standards/specifications.

data items. The intersections of each column with the selected rows from the system and program descriptors are the significant cells of the matrix.

In Table 3-1, these cells contain a dummy code letter (X, Y, Z, etc.) if the significance is such that a specification item is to be applied. In the system descriptor cells, the use of different dummy letters under a single specification area denotes that, although the specification item is to apply in each cell, different paragraphs would be applicable. In the completed handbook these symbols would be replaced by applicable paragraph numbers from Sections 3, 4, and 5 of the handbook. Or, to keep the matrix from becoming unwieldy, they might be replaced by numbers referring to tabulations of paragraph numbers on separate pages.

The dummy letters in cells corresponding to program descriptors have a somewhat different connotation. In these cells the letters would be replaced by numbers referring to a tabulation of qualifying remarks. For example, the "X" in the cell at the intersection of the descriptors "Potential Production Quantity, 1-10 Units" and "Reliability and Maintainability" might refer to a note telling the program manager that reliability predictions made according to MIL-HDBK-217 may suffice in lieu of life testing.

3.4 DESIGN CHECKLIST

To ensure that all applicable design factors have been examined, a checklist will be incorporated into the handbook for use by program managers and/or system designers. The subject matter will be divided into the same areas as those of the handbook, i.e., airframe, avionics, design standards, environmental, maintainability, manufacturing, power, propulsion, reliability, and safety. Entries in each category will be keys to ensure that all design aspects of the program are either contractually covered or have been purposely omitted. Similarly, the system designers may use the checklist to make sure that proper attention is given to each functional aspect of the system. Not all areas will be applicable to a specific program, so the user will have to be selective.

3.5 CONTRACT FORMAT

Applicable specification paragraphs given in the design handbook can be implemented in two ways as a contract document for a specific procurement. One way is to make the handbook itself a contract document. This would require that the program manager supply an addendum calling out the applicable paragraphs appearing in the handbook matrix of program task versus applicable specification requirement. The other approach is for the program manager to select the appropriate paragraphs from the handbook and then construct a specification to a standardized format. (Such a format as described in MIL-STD-490, Appendix II, could be included as an appendix to the handbook.) That specification would thus stand alone as the contract document for all specification and data-item provisions.

4
SCOPE OF DESIGN HANDBOOK

A design handbook will be only as useful as it is well-organized, flexible, and simple. An overly complicated handbook will be difficult to maintain and will suffer from the same problem that it intends to correct – the difficulties in applying the proper military specifications and standards. Moreover, some aspects of drone/RPV aircraft design are already adequately covered by design handbooks and applicable specifications written for manned aircraft and missile procurement. A design handbook for drone/RPV procurement and modification should cover in detail those areas of airframe, avionics, and the "-ilities" where man-rating details applicable to manned aircraft cause overdesign and unnecessary costs when imposed on drone programs.

Cost savings can also be achieved in areas other than deleting man-rating details in the specifications. Existing specifications and standards should be modified so that, in general, only those portions applicable to drone/RPV programs will be integrated into the design handbook.

DoD regulations specifically require direct use of certain military specifications and standards for some types of procurement, as discussed in Section 9. The design handbook must be organized to accommodate this requirement.

4.1 DESIGN HANDBOOK COVERAGE

The drone/RPV design handbook should generally cover the following areas:

a. Airframe
b. Propulsion
c. Power
d. Environmental Conditions
e. Avionics
f. Maintainability
g. Reliability
h. Safety
i. Design Standards

j. **Manufacturing**

k. **Quality Assurance**

Functional performance (detailed mission) requirements and management techniques should not be considered in the handbook except as they relate to included technical specification material. Support equipment should be covered as it relates to drone/RPV operational peculiarities, perhaps in a separate handbook section.

4.2 SUBSIDIARY SPECIFICATIONS

Many specifications make internal reference to other specifications, both in the text and in a separate paragraph entitled "Applicable Documents". These referenced documents may become part of that specification depending on the manner in which they are discussed. The referenced documents may themselves call out subsidiary specifications, so that the cumulative set of "applicable specifications" can become almost overwhelming.

The drone/RPV design handbook should break precedent by deleting, where possible, all reference to subsidiary specifications. In those instances where referenced documents in primary specifications are related to the drone/RPV program and are important to a contractual agreement with the contractor, the referenced documents will be added to the basic specifications listed in the handbook. Other cases may permit reliance on contractor design practices and procedures, in lieu of specifications, through the use of appropriate wording in the handbook sections.

Certain military specifications and standards are required by regulation or directive to be explicitly referenced in a procurement contract. Section 9, a discussion of Air Force procurement policies, offers some details in this regard. Where such requirements exist, the design handbook should give appropriate guidance to the program manager.

5
DOCUMENTATION NOW USED IN DRONE/RPV PROGRAMS

Military specifications and standards now being used in drone/RPV acquisition and modification programs were determined from:

a. Interviews with Air Force and industry personnel

b. A review of documentation relating to various Air Force drone programs, Compass Bright, and the Navy MQM-74C.

From the interviews, ARINC Research was guided to the applicable aircraft and/or system detail specifications. These specifications were then examined to determine whether they required full compliance, partial compliance, or guidance from the specifications and standards referenced therein. (It is understood that the actual contracts may have required still further data items as a result of ASPRs, DoD regulations, or special interest influences. ASPRs – Armed Services Procurement Regulations – will be dealt with in a later section of this report.)

Table 5-1 is a compilation of the results of the above effort. In Air Force programs, it was found that the Ryan AQM-34R was required to have full compliance with the greatest number of specifications and standards (13), with the Lear-Seigler YAQM-34U next (10). It is interesting to note that while the YAQM-34U program was primarily an avionics change to an existing drone (the AQM-34L), it contained only three fewer full-compliance documents.

The Navy MQM-74C was required to have full compliance with 32 military specifications. The procurement was generated in conformance with MIL-T-18232B, Military Specification, Targets, Aerial, Powered, Design and Construction of, General Specifications for.

No airframe specifications or standards were required for any Air Force programs. Configuration standards were specified only for the YAQM-34U and Compass Bright, and in the former case only as a guide.

It was determined that engine documentation for Air Force programs is handled separately from that of the aircraft. The type of engine is specified by the program prime contractor, and it is then supplied to him by the Air Force as GFE. The MIL-E-5007 series is used as the primary specification set for engines.

During the above-mentioned interviews, specific specifications and standards were discussed to obtain industry and military opinion as to their effectiveness. These comments are summarized in Table 5-2. Table 5-3 contains additional comments not directly addressing individual specifications or standards, but applicable to drone/RPV programs.

TABLE 5-1. MILITARY SPECIFICATIONS AND STANDARDS USED IN SPECIFIC DRONE/RPV PROGRAMS (Sheet 1 of 5)

Number	Topic Covered	Drone/RPV Manufacturer and Type						
		Ryan				LSI	Compass	Northrop
		147S	AQM-34M	AQM-34Q	AQM-34R	YAQM-34U	Bright	MQM-74C
●STANDARDS								
MIL-STD-129	Identification	F	F	F	F			F
MIL-STD-130D	Identification					F		F
MIL-STD-143	Order of spec precedence		F	F	F			F
MIL-STD-210	Climatic extremes							
MIL-STD-454	Electronic equipment		P(1)		P(1)	F		
MIL-STD-461A	EMI					F		F
MIL-STD-462	EMI					F		
MIL-STD-470	Maintainability						P(2)	
MIL-STD-480	Configuration					G		
MIL-STD-481	Configuration						G	
MIL-STD-482	Configuration						G	
MIL-STD-483	Configuration					G	G	
MIL-STD-490	Specifications					G		
MIL-STD-704	Electric power			F	F	F		F
MIL-STD-756A	Reliability					F		
MIL-STD-781B	Reliability tests						P(3)	
MIL-STD-785A	Reliability						P(4)	
MIL-STD-790	Reliability						F	
MIL-STD-794	Packaging				P(5)			
MIL-STD-810	Environmental			F		P(6)		
MIL-STD-838B	Lubricants	F	F	F	F			
MIL-STD-881	Work breakdown						F	

NOTES:

a. F - Full compliance required
b. G - Guidance only
c. P(x) - Partial compliance required; see last page of this table for explanation
d. Boeing "Compass Cope" used in-house specifications only
e. Inactive, according to Military Specifications Index; no title available

TABLE 5-1. (Sheet 2 of 5)

Number	Topic Covered	Drone/RPV Manufacturer and Type						
		Ryan				LSI	Compass	Northrop
		147S	AQM-34M	AQM-34Q	AQM-34R	YAQM-34U	Bright	MQM-74C
●STANDARDS (Continued)								
MIL-STD-882	System safety				P(7)	F	F	P(8)
MIL-STD-891	Standardization					-	F	
MIL-STD-1472	Design				G	G		
●SPECIFICATIONS								
MIL-S-901	Shock tests							F
MIL-D-1000	Drawing guide					G		
MIL-B-5087	Bonding	G	F	G	F			P(9)
MIL-B-5088	Wiring		F		F			
MIL-E-5400	Electronic equipment	F				F		P(10)
MIL-F-5572	Fuel							F
MIL-T-5624	Fuel		F		F			P(11)
MIL-V-5636	Valves							F
MIL-E-6051	EMI compatibility	G	F	G	F	G		F
MIL-I-6181*	Interference control	G	F	G	F			F
MIL-T-6896	Fuel, oil							F
MIL-I-7032	Inverter	F	F	F				
MIL-I-7171	Insulation blanket							F
MIL-F-7179	Finishes & coatings							F
MIL-C-7244*	Servicing	G	F	F				
MIL-P-7620	Parachute							P(12)
MIL-C-7742*	(See note e)							F
MIL-M-7793	Meter							
MIL-L-7808	Lubrication	F	F	F	F			F
MIL-P-8013*	(See note e)							F
MIL-W-8160	Wiring	F	F		F			P(13)
MIL-I-8500	Component parts							F

*Inactive according to Military Specifications Index

TABLE 5-1. (Sheet 3 of 5)

Number	Topic Covered	Drone/RPV Manufacturer and Type						
		Ryan				LSI	Compass	Northrop
		147S	AQM-34M	AQM-34Q	AQM-34R	YAQM-34U	Bright	MQM-74C
●SPECIFICATIONS (Continued)								
MIL-C-8678	Cooling req. power plant							F
MIL-H-8775	Hydraulic system comp.							F
MIL-H-8795	Hose assembly		G					
MIL-A-8860	Strength and rigidity							F
MIL-A-8870	Vibration flutter	G	G	G				
MIL-S-9041	Sandwich construction							F
MIL-C-9084	Lamination							F
MIL-Q-9858	Quality control		F	F	F		G	F
MIL-F-17874	Fuel systems							F
MIL-C-18263	Colors							F
MIL-N-18307	Nomenclature & name plates							F
MIL-H-18325	Heating and vent system							P(16)
MIL-F-18372	Flight control system							F
MIL-I-18464	Markings							P(14)
MIL-S-19500	Semiconductors						F	
MIL-T-21200	Test equipment						F	
MIL-D-21625	Cartridges							F
MIL-R-22449	Pyrotechnic items							F
MIL-D-23615	Actuated cartridges							F
MIL-I-23659	Electronic initiator							F
MIL-L-23699	Lubricating oil							F
MIL-P-24014	Electronic radiation							F
MIL-P-25062	Parachute							P(15)
MIL-M-25095A	Maintenance						F	
MIL-E-25366	Missile electronic equip.	F	F	F	F			F
MIL-D-26239	Personnel					G		

TABLE 5-1. (Sheet 4 of 5)

Number	Topic Covered	Drone/RPV Manufacturer and Type						
		Ryan				LSI	Compass Bright	Northrop
		147S	AQM-34M	AQM-34Q	AQM-34R	YAQM-34U		MQM-74C
●SPECIFICATIONS (Continued)								
MIL-H-27894**	(See note e)					G		
MIL-M-38510	Microcircuits						F	
MIL-M-38797	Technical Manual						F	
MIL-M-38800	Technical Manual						F	
MIL-C-38999	Connector					F		
MIL-H-46855	Human engineering					G		
MIL-C-82723**	(See note e)					F		
MIL-HDBK-5	Metallic materials and elements							

**Not listed in Military Specifications Index.

TABLE 5-1. (Sheet 5 of 5)

NOTES

P(1) Requirement 9 only
P(2) Para. 5.1
P(3) Para. 5.1.1 (except second sentence)
P(4) Paras. 5.1.2.1, 5.1.3, 5.1.4, 5.2.3 (except last sentence); 5.2.9 (except (3) and (5)); 5.4.1, and 5.4.2
P(5) Except 5.6.1 and Appendix C
P(6) Method 507, Procedure 1; Method 514, Procedure 11; Method 516, Procedure 1
P(7) Safety Sections 4.1, 5.4, 5.6
P(8) Following paragraphs used as guide: 3, 4.2.4, 4.2.5, 4.3, 5.3.1, 5.4.1, 5.5, 5.7, 5.8.1, 5.8.1.1, 5.8.2.4, 5.9, 6.1, 6.2, and 9
P(9) Except lightning protection not required
P(10) "Shall be in accordance with MIL-E-5400 for Class 1A equipment except that:
- (A) Shock requirement for mounting bases shall be 15g for crash safety.
- (B) Printed wiring boards utilizing the conductor pattern as the direct contact with the mating connector may be used.
- (C) Requirements for cases and mounting bases (MIL-C-172 and MIL-M-81288) are not applicable.
- (D) Maximum altitude shall be 40,000 feet and maximum operating temperature shall be +165° F."

P(11) "The liquid propellants shall be in accordance with MIL-T-5624 fuel, grade JP-5, except that starting with JP-5 fuel shall not be required below an ambient temperature corresponding to a fuel viscosity of 12 centistokes. When using MIL-T-5624, grade JP-4, as an alternate fuel, the engine shall perform as specified throughout its complete operating range as specified in Williams Research Corporation Specification MSWR 24-7B."
P(12) Except that air permeability tests of completed canopies are not required.
P(13) Except that waterproof connectors are not required within sealed equipment compartments and that wire identification in accordance with MIL-W-8160 is not required.
P(14) Except that self-locking nuts without lock wire may be used. Screws (10-32) may be used for single attachment where design limit loads permit. Torque tubes shall be supported in bearings compatible with design loads.
P(15) With the following exceptions:
- (A) A single battery and normal recovery delay timer shall be utilized.
- (B) The parachute system shall be capable of safe recovery for the normal recovery mode throughout the flight envelope. For the instant chute recovery mode, the system shall be capable of recovery at 300 KTAS maximum with a safety factor of 1.25.
- (C) The parachute compartment is located so that the normal deployment path passes over a tail surface. There shall be no entanglement or damage to the parachute which will preclude safe recovery of the target during deployment due to interference with any part of the target.
- (D) The design of the compartment and method of closure may not provide adequate sealing to keep the parachute completely dry. Dry materials utilized in the recovery system shall not be degraded by the presence of moisture and shall be capable of successfully operating after exposure to this environment.
- (E) The safety factors for recovery initiation, as specified in paragraph 3.3.2.1, shall apply for all components of the recovery system when applied to the critical limit loads for each component.
- (F) In lieu of a deployment bag, a suitably designed compartment liner with integral protective flaps may be used. Apex first deployment of the main parachute may be used.
- (G) The main parachute system may be deployed at any altitude within the flight envelope of the target. Altitude control device is not required.
- (H) The battery need not be heated to prevent temperature from falling below 30°F.

TABLE 5-2. SUMMARY OF MILITARY AND INDUSTRIAL COMMENTS CONCERNING STANDARDS AND SPECIFICATIONS (Sheet 1 of 4)

(The following comments are individual opinions, and should not be taken as a consensus for any particular standard or specification. However, to the extent that at least one qualified individual has chosen to remark on the usefulness of a particular standard or specification, consideration should be given to that viewpoint.)

Standard/Spec	Short Title	Comment(s) Concerning Standard/Specification
MIL-STD-210	Climatic Extremes	This standard should be used, but only to the extent of mission and operational environment.
MIL-STD-454	Gen'l Rqmts, Electronic Eqpt	Portions of Requirement 1 should always be called out, but a grounding rod cannot be implemented on RPV's. Safety is not affected by the absence of this rod, since the RFI specification necessitates adequate vehicle grounding.
MIL-STD-461 -462	Electromagnetic Interference	Portions of these documents should always be called out, since they may be critical to the meeting of mission requirements. Rather than specifying test programs and requirements, a handbook containing good design practices would be more useful.
MIL-STD-470	Maintainability Requirements	Should be used for developing a maintainability program.
MIL-STD-471	Maintainability Demonstration	Should be modified for program type and used when maintainability demonstration is required.
MIL-HDBK-472	Maintainability Prediction	Should be modified for program type and used if only a maintainability analysis is required.
MIL-STD-480	Configuration Control	Should not cost the government any additional money to specify, and should be used across the board.
MIL-STD-483	Configuration Management	Must be modified for each program and should not be treated in the handbook since the SPO can handle this.

TABLE 5-2. (Sheet 2 of 4)

Standard/Spec	Short Title	Comment(s) Concerning Standard/Specification
MIL-STD-490	Specification Practices	Should not cost the government any additional money to specify, and should be used across the board.
MIL-STD-499	Systems Engrg. Mgmt.	There should be a strong interface specification. MIL-STD-499 was used on the F-15, but was found to be insufficient.
MIL-STD-704	Aircraft Electric Power	Portions of this specification should always be called out.
MIL-STD-781	Reliability Tests, Exp. Distr.	Not presently used for testing of engines. Maybe some statistical means should be used, rather than trying to achieve "square corners" on test curves.
MIL-STD-785	Reliability Pgm. Rqmts.	Should be used for developing a reliability plan.
MIL-STD-801B	Environmental Test Methods	Ryan used its own environment design and test requirements (Ryan 14759-100-1). These documents reference specific sections of MIL-STD-810. When a procurement specification (e.g., for the AQM-34R) requires that MIL-STD-810 apply, Ryan then uses the above mentioned documents to meet this requirement.
MIL-STD-881	Work Breakdown Structures	A work breakdown structure should be generated for drone/RPV programs. MIL-STD-881 is presently being modified for each drone.
MIL-STD-882	System Safety Program	This standard establishes guidelines for a system program. Implementation of this document is very costly, but shouldn't be: most of the specified effort is merely good engineering design practices which should be observed anyway.
MIL-STD-883	Microelectronic Testing	Rather than calling out this specification, a burn-in requirement for all integrated circuits may be cheaper. A contradictory comment was that component burn-in is not practical for small-quantity programs.

TABLE 5-2. (Sheet 3 of 4)

Standard/Spec	Short Title	Comment(s) Concerning Standard/Specification
MIL-STD-1472	Human Engineering	Should be modified and used as design criteria.
MIL-STD-1530	A/C Structural Integrity	Paragraph 1.2.1 (how to apply the standard to RPV's) is wide open for interpretation.
MIL-D-1000	Engineering Drawings	To save money, engineering drawings should be called out rather than requiring full MIL-D-1000 compliance. Rather than just specifying company-type engineering drawings, MIL-D-1000 type 1, 2, 3 drawings can be specified at the same price.
MIL-E-5007, -5008, -5009	Aircraft Turbojet Engines	Used by the engine group at the drone/RPV SPO as the main guidelines for writing engine specifications. Any handbook dealing with engines should call out this series (some modifications may be applicable), but should not try to be a guide to specification use. For specific changes in MIL-E-5007, see Vol. III, Part 1, Study of Multi-Mission RPV Systems, ASD/XR72-11.
MIL-E-5400	Airborne Electronic Eqpt.	Vibration and high-operating temperature tests may be too severe. Air requirements on cooling are important. Water-soak test cannot be passed unless all boxes are hermetically sealed.
MIL-E-8189	Missile Electronic Eqpt.	Specification is good except for vibration requirement, which is too stringent.
MIL-I-8500	Component Interchangeability	Interchangeability of component parts for a high-loss, low-cost vehicle is too expensive.
MIL-M-8555	Missile Design and Constr.	More applicable than MIL-A-8860. A modified version should be used for RPV's. For specific changes in MIL-M-8555 and -8856, see Vol. III, Part 1, Study of Multi-Mission RPV Systems, ASD/XR72-11.

TABLE 5-2. (Sheet 4 of 4)

Standard/Spec	Short Title	Comment(s) Concerning Standard/Specification
MIL-M-8856	Missile Strength/Rigidity	Parts of this document should probably be used in a handbook.
MIL-A-8860	Airplane Strength/Rigidity	Parts of this document should probably be used in a handbook.
MIL-Q-9858	Quality Program Rqmts.	Generally a good specification except for specific sections, which impose costly and possibly unnecessary requirements for a drone/RPV program. For example a reliability plan should not be a contract data item, and such things as quality trend charts are not applicable to limited-production programs.
MIL-F-17874	Aircraft Fuel Systems	Strongly oriented toward manned aircraft, with little practical application to drone/RPV systems.
MIL-T-18232	Powered Aerial Targets	Has sections highly applicable to drone/RPV systems. Used by the Navy as the primary specification for drones.

TABLE 5-3. ADDITIONAL COMMENTS RELEVANT TO DRONE/RPV DESIGN HANDBOOK (Sheet 1 of 2)

(The following comments, obtained through interviews with Air Force and industry personnel, generally relate to content and use of a drone/RPV design handbook. Comments were gathered from several sources, and are not necessarily consistent with each other or with the conclusions drawn from the overall study.)

1. A design handbook would establish a uniform method of generating drone/RPV specifications.

2. Maintaining the handbook in an up-to-date status is very important.

3. An RPV design handbook would be more helpful as a guideline than as a hard specification.

4. A design handbook for engines should contain general performance specifications, but not "how to build" information. This should be left up to the manufacturers.

5. It is doubtful that a mission-oriented handbook use-matrix can be used since the mission may not initially be defined clearly.

6. Reliability, maintainability, and safety specifications impact strongly on costs. If we can "tighten" these specifications, we will have something worthwhile.

7. A design handbook cannot be used as a contractual vehicle in lieu of specifications and standards unless the handbook has the proper level of authority. ASPRs may also conflict with the handbook.

8. Rather than specifying whole documents, the handbook should call out only those sections that are applicable.

9. Cost restraints that have a detrimental effect on mission survivability must be avoided.

10. Redundant systems should be required where the failure of one component will result in the loss of a vehicle.

11. A flying test bed should be used for avionics testing rather than an RPV.

12. Commercial-grade components should be used when adequate.

13. Cost cutting can be achieved by reducing the structural load factors of an RPV versus those of manned craft.

14. The impact of a specification on ten-year life cycle costs would be a good gauge of its value.

TABLE 5-3. (Sheet 2 of 2)

15. Demanding the use of standard parts will hinder the development of new technology. A contractor should be allowed to use nonstandard parts as long as he supplies backup data.

16. An RPV need not be as reliable as a manned craft.

17. We may need to build drones better than manned craft because of mission criticality.

18. Certain specifications and standards are required for all procurement levels, but should be only as rigorous as necessary at each level to accomplish the task.

19. Expendable drones are not a "good concept". During peacetime, birds will be kept in operation long after the specified life has expired.

20. A good working relationship between the Air Force and its contractors is the monitoring force in many areas of specification compliance.

21. Feasibility demonstrations are not as good as competitive development, because only one viewpoint is obtained.

22. In competitive prototype development and feasibility demonstrations, the contractor should be allowed to build the bird in any manner he wants as long as performance requirements are met.

23. CFE procurement of engines is the least expensive method during system development. GFE appears to be the least expensive method during the production phase.

24. Engines take a five to six-year development cycle.

6
DOCUMENTATION APPLICABLE TO DRONE/RPV PROGRAMS

This investigation revealed that, in addition to the documentation now being used in drone/RPV acquisition and modification programs (see Section 5), a considerable body of additional handbooks, specifications, and standards could prove beneficial. These additional documents, together with those presently being used, are combined into comprehensive listings of applicable documents in Tables 6-1 and 6-2. These tables contain the same information, with Table 6-1 listing the documents numerically and Table 6-2 according to general category (airframe, etc.).

These listings primarily reflect top-level documentation. Subsidiary specifications are not included since the referencing of all of them is not really necessary and would overly complicate the handbook content. For example, specifications pertaining to the quality of components, fasteners, finishes and the like could be excluded and the statement made (where appropriate) that components shall be MIL-qualified, AN fasteners shall be used, etc. Any specific subsidiary documents that should be included in the design handbook could be established during the detailed investigation accompanying the development of the handbook.

The Table 6-1 listing was developed in the following manner:

a. A candidate list was initiated from all system documentation and specification trees thought to be applicable. These documents were studied for other suitable references, which were added to the list. The compilation at this point totalled some 200 documents.

b. The applicability of each document on the list was determined from a cursory review of content, currentness (is it listed in the DoD Index?), interviews with military and industrial personnel, and engineering judgment. More than half of the specifications and standards reviewed were considered inappropriate for drone/RPV design and were deleted.

Table 6-1 lists 91 top-level documents believed to be applicable to a drone/RPV design handbook. For about 40 documents on the list (denoted by asterisks), this should be verified through a careful evaluation of the documents during the development of the handbook.

Table 6-2 was developed from Table 6-1 by grouping the list of specifications and standards into the following ten categories: Airframe, Propulsion, Power, Environmental, Avionics, Maintainability, Reliability, Safety, Design Standards, and Manufacturing. It is felt that categorization in this manner will facilitate integration of the documentation into a handbook format.

TABLE 6-1. SPECIFICATIONS AND STANDARDS APPLICABLE TO DRONE/RPV HANDBOOK (LISTED NUMERICALLY) (Sheet 1 of 6)

Number	Title	Category
●HANDBOOK		
MIL-HDBK-217	Reliability Stress and Failure Rate Data for Electronic Equipment	Reliability
MIL-HDBK-275*	Guide for Selection of Lubricants, Fluids, and Compounds for Use in Flight Vehicles and Components	Design Standards
MIL-HDBK-472	Maintainability Prediction	Maintainability
AFSC DH1-2	General Design Factors	Design Standards
AFSC DH1-4	Electromagnetic Compatibility	Avionics
AFSC DH1-5	Environmental Engineering	Environmental
AFSC DH1-6	System Safety	Safety
AFSC DH1-8*	Microelectronics	Design Standards
AFSC DH1-9	Maintainability	Maintainability
AFSC DH1-X	Checklist	Various
AFSC DH2-1	Airframe	Airframe
AFSC DH2-3	Propulsion and Power	Propulsion
●STANDARDS		
AFP-800-7*	Integrated Logistic Support (Implementation Guide for DoD Systems and Equipments)	Design Standards
MIL-STD-143*	Standards & Specifications, Order of Precedence for the Selection of	Design Standards
MIL-STD-188*	Military Communications System Technical Standards	Avionics
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts	Reliability
MIL-STD-210	Climatic Extremes for Military Equipment	Environmental
MIL-STD-242*	Electronic Equipment Parts Parts 1-5)	Design Standards
MIL-STD-442*	Aerospace Telemetry Requirements	Avionics

TABLE 6-1. (Sheet 2 of 6)

Number	Title	Category
•STANDARDS (Cont)		
MIL-STD-446	Environmental Requirements for Electronic Parts	Environmental
MIL-STD-453*	Inspection, Radiographic	Reliability
MIL-STD-454	Standard General Requirements for Electronic Equipment	Design Standards
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment	Avionics
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of	Avionics
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipment)	Maintainability
MIL-STD-471	Maintainability Demonstration	Maintainability
MIL-STD-480*	Configuration Control Engineering Changes, Deviations & Waivers	Design Standards
MIL-STD-481	Configuration Control-Engineering Changes & Waivers (Short Form)	Design Standards
MIL-STD-483*	Configurations Management Practices for Systems, Equipment, Munitions, and Computer Programs	Design Standards
MIL-STD-490	Specification Practices	Design Standards
MIL-STD-499*	Systems Engineering Management	Design Standards
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of	Power
MIL-STD-721*	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety	Design Standards
MIL-STD-750*	Test Methods for Semiconductor Devices	Reliability
MIL-STD-756	Reliability Prediction	Reliability
MIL-STD-757*	Reliability Evaluation from Demonstration Data	Reliability

TABLE 6-1. (Sheet 3 of 6)

Number	Title	Category
●STANDARDS (Cont)		
MIL-STD-785*	Requirements for Reliability Program (for Systems and Equipment)	Reliability
MIL-STD-810	Environmental Test Methods	Environmental
MIL-STD-838*	Lubrication of Military Equipment	Design Standards
MIL-STD-881	Work Breakdown Structures for Defense Material Items	Design Standards
MIL-STD-883*	Test Methods and Procedures for Microelectronics	Reliability
MIL-STD-891*	Contractor S Parts Control and Standardization Program	Design Standards
MIL-STD-882	System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for	Safety
MIL-STD-1472	Human Engineering Design Criteria of Military Systems, Equipment and Facilities	Design Standards
MIL-STD-1516	Coating for Aircraft and Missiles	Manufacturing
MIL-STD-1530*	Aircraft Structural Integrity Program, Airplane Requirements	Airframe
●SPECIFICATIONS		
MIL-T-152*	Treatment, Moisture and Fungus Resistant, of Communications, Electronic, and Associated Electrical Equipment	Manufacturing
MIL-D-1000	Drawings, Engineering and Associated List	Design Standards
MIL-E-5007	Engine, Aircraft, Turbojet and Turbofan, General Specifications for	Propulsion
MIL-E-5008	Engine, Aircraft, Turbojet, Model Specification for (Outline and Instructions for Preparation)	Propulsion
MIL-E-5009	Engine, Aircraft, Turbojet and Turbofan, Tests for	Propulsion
MIL-W-5013*	Wheel and Brake Assemblies, Aircraft	Airframe

TABLE 6-1. (Sheet 4 of 6)

Number	Title	Category
	●SPECIFICATIONS (Cont)	
MIL-B-5087*	Bonding, Electrical, and Lightning Protection, for Aerospace Systems	Power
MIL-W-5088*	Wiring, Aircraft, Installation of	Power
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for	Environmental
MIL-E-5400	Electronic Equipment, Airborne, General Specification for	Avionics
MIL-T-5422	Testing, Environmental, Aircraft Electronic (Testing for Compliance to MIL-E-5400)	Environmental
MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design, Installation and Data Requirements for	Airframe
MIL-C-5462*	Cover; Wing and Tail, Aircraft, General Specifications for	Airframe
MIL-P-5518	Pneumatic Systems, Aircraft, Design Installation, and Data Requirements for	Airframe
MIL-I-6051	Electrical - Electronic System Capability and Interference Control Requirements for Aeronautical Weapon Systems and Associated Subsystems	Avionics
MIL-G-6099*	Generators and Regulators, Air Cooled, A-C, Aircraft, General Specification	Power
MIL-I-6868*	Inspection Process, Magnetic Particle	Reliability
MIL-F-7179*	Finishes and Coatings, General Specification for Protection of Aircraft and Aircraft Parts	Manufacturing
MIL-R-7705	Radomes, General Specification for	Avionics
MIL-W-8160	Wiring, Guided Missile, Installation of, General Specification for	Power
MIL-E-8189	Electronic Equipment, Guided Missiles, General Specification for	Avionics

TABLE 6-1. (Sheet 5 of 6)

Number	Title	Category
•SPECIFICATIONS (Cont)		
MIL-I-8500*	Interchangeability and Replaceability of Component Parts for Aircraft and Missiles	Avionics
MIL-M-8555	Missiles, Guided: Design and Construction, General Specification for	Design Standards
MIL-C-8591*	Airborne Stores and Associated Suspension Equipment, General Design Criteria for	Airframe
MIL-M-8856	Missiles, Guided, Strength and Rigidity Requirements	Airframe
MIL-A-8860	Airplane Strength and Rigidity, General Specification for	Airframe
MIL-P-9400*	Plastic Laminate Materials and Sandwich Construction, Glass Fiber Base, Low Pressure Aircraft, Structural, Process Specification Requirements	Manufacturing
MIL-Q-9858	Quality Program Requirements	Reliability
MIL-P-11268	Parts, Materials, and Processes Used in Electronic Equipment	Design Standards
MIL-E-11991*	Electronic, Electrical, and Electro-mechanical Equipment, Guided Missile Weapon Systems, General Specification for	Avionics
MIL-T-18232	Target, Aerial, Powered, Design and Construction of General Specification for	Design Standards
MIL-N-18307	Nomenclature and Nameplates for Aeronautical Electronic and Associated Equipment	Avionics
MIL-E-19600*	Electronic Modules, Aircraft, General Requirements for	Avionics
MIL-R-22973*	Reliability Index Determination for Avionic Equipment Models, General Specification for	Reliability

TABLE 6-1. (Sheet 6 of 6)

Number	Title	Category
●SPECIFICATIONS (Cont)		
MIL-S-23069	Safety Requirements, Minimum for Air Launched Guided Missiles	Safety
MIL-M-24100*	Manuals, Orders and Other Technical Instructions for Equipment and Systems	Design Standards
MIL-E-25366	Electric and Electronic Equipment and System, Guided Missile, Installation of, General Specifications for	Avionics
MIL-H-25475	Hydraulic System, Missile Design, Installation Tests, and Data Requirements, General Specification for	Airframe
MIL-E-25499	Electrical Systems, Aircraft, Design and Installation of, General Specification for	Power
MIL-D-26239*	Data, Qualitative and Quantitative Personnel Requirements Information (QQPRI)	Design Standards
MIL-F-38363*	Fuel System, Aircraft, Design Performance, Installation, Testing, and Data Requirements, General Specifications for	Propulsion
MIL-M-38784*	Manual, Technical, General Requirements for Preparation of	Design Standards
MIL-I-45208*	Inspection System Requirements	Reliability
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities	Design Standards
MIL-P-55110*	Printed Wiring Boards	Manufacturing
MIL-A-83116*	Air Conditioning Subsystems, Air Cycle, Aircraft and Aircraft-Launched Missiles, General Specifications for	Environmental

*Possibly applicable.

TABLE 6-2. SPECIFICATIONS AND STANDARDS APPLICABLE TO DRONE/RPV HANDBOOK (LISTED BY CATEGORY)
(Sheet 1 of 6)

Number	Title	Category
MIL-STD-1530*	Aircraft Structural Integrity Program, Airplane Requirements	Airframe
MIL-W-5013*	Wheel and Brake Assemblies, Aircraft	
MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design, Installation and Data Requirements for	
MIL-C-5462*	Cover; Wing and Tail, Aircraft, General Specification for	
MIL-P-5518	Pneumatic Systems, Aircraft, Design Installation, and Data Requirements for	
MIL-C-8591*	Airborne Stores and Associated Suspension Equipment, General Design Criteria for	
MIL-M-8856	Missiles, Guided, Strength and Rigidity Requirements	
MIL-A-8860	Airplane Strength and Rigidity, General Specification for	
MIL-H-25475	Hydraulic System, Missile Design, Installation Tests, and Data Requirements, General Specification for	
AFSC DH2-1	Airframe	Airframe
MIL-STD-188*	Military Communications System Technical Standards	Avionics
MIL-STD-442*	Aerospace Telemetry Requirements	
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment	
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of	
MIL-E-5400	Electronic Equipment, Airborne, General Specification for	
MIL-I-6051	Electrical - Electronic System Capability and Interference Control Requirements for Aeronautical Weapon Systems and Associated Subsystems	Avionics

TABLE 6-2. (Sheet 2 of 6)

Number	Title	Category
MIL-R-7705	Radomes, General Specification for	Avionics
MIL-E-8189	Electronic Equipment, Guided Missiles, General Specification for	
MIL-I-8500*	Interchangeability and Replaceability of Component Parts for Aircraft and Missiles	
MIL-E-11991*	Electronic, Electrical, and Electro-mechanical Equipment, Guided Missile Weapon Systems, General Specification for	
MIL-N-18307	Nomenclature and Nameplates for Aeronautical Electronic and Associated Equipment	
MIL-E-19600*	Electronic Modules, Aircraft, General Requirements for	
MIL-E-25366	Electric and Electronic Equipment and System, Guided Missile, Installation of, General Specifications for	
AFSC DH1-4	Electromagnetic Compatibility	Avionics
MIL-HDBK-275*	Guide for Selection of Lubricants, Fluids, and Compounds for Use in Flight Vehicles and Components	Design Standards
MIL-STD-143*	Standards & Specifications, Order of Precedence for the Selection of	
MIL-STD-242*	Electronic Equipment Parts (Parts 1-5)	
MIL-STD-454	Standard General Requirements for Electronic Equipment	
MIL-STD-480*	Configuration Control Engineering Changes, Deviations & Waivers	
MIL-STD-481	Configuration Control-Engineering Changes & Waivers (Short Form)	
MIL-STD-483*	Configurations Management Practices for Systems, Equipment, Munitions, and Computer Programs	
MIL-STD-490	Specification Practices	Design Standards

TABLE 6-2. (Sheet 3 of 6)

Number	Title	Category
MIL-STD-499*	Systems Engineering Management	Design Standards
MIL-STD-721*	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety	
MIL-STD-838*	Lubrication of Military Equipment	
MIL-STD-881*	Work Breakdown Structures for Defense Material Items	
MIL-STD-891*	Contractor S Parts Control and Standardization Program	
MIL-D-1000	Drawings, Engineering and Associated List	
MIL-STD-1472	Human Engineering Design Criteria of Military Systems, Equipment and Facilities	
MIL-M-8555	Missiles, Guided: Design and Construction, General Specification for	
MIL-P-11268	Parts, Materials, and Processes Used in Electronic Equipment	
MIL-T-18232	Target, Aerial, Powered, Design and Construction of General Specification for	
MIL-M-24100*	Manuals, Orders and Other Technical Instructions for Equipment and Systems	
MIL-D-26239*	Data, Qualitative and Quantitative Personnel Requirements Information (QQPRI)	
MIL-M-38784*	Manual, Technical, General Requirements for Preparation of	
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities	
AFSC DH1-2	General Design Factors	
AFSC DH1-8*	Microelectronics	
AFP-800-7*	Integrated Logistic Support (Implementation Guide for DoD Systems and Equipments)	Design Standards
MIL-STD-210	Climatic Extremes for Military Equipment	Environmental
MIL-STD-446	Environmental Requirements for Electronic Parts	Environmental

TABLE 6-2. (Sheet 4 of 6)

Number	Title	Category
MIL-STD-810	Environmental Test Methods	Environmental
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for	
MIL-T-5422	Testing, Environmental, Aircraft Electronic (Testing for Compliance to MIL-E-5400)	
MIL-A-83116*	Air Conditioning Subsystems, Air Cycle, Aircraft and Aircraft-Launched Missiles, General Specification for	
AFSC DH1-5	Environmental Engineering	Environmental
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipment)	Maintainability
MIL-STD-471	Maintainability Demonstration	
MIL-HDBK-472	Maintainability Prediction	
AFSC DH1-9	Maintainability	Maintainability
MIL-T-152*	Treatment, Moisture and Fungus Resistant, of Communications, Electronic, and Associated Electrical Equipment	Manufacturing
MIL-STD-1516	Coating for Aircraft and Missiles	
MIL-F-7179*	Finishes and Coatings, General Specifications for Protection of Aircraft and Aircraft Parts	
MIL-P-9400*	Plastic Laminate Materials and Sandwich Construction, Glass Fiber Base, Low Pressure Aircraft, Structural, Process Specification Requirements	
MIL-P-55110*	Printed Wiring Boards	Manufacturing
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of	Power
MIL-B-5087*	Bonding, Electrical, and Lighting Protection, for Aerospace Systems	Power
MIL-W-5088*	Wiring, Aircraft, Installation of	Power

TABLE 6-2. (Sheet 5 of 6)

Number	Title	Category
MIL-G-6099*	Generators and Regulators, Air Cooled, A-C, Aircraft, General Specification	Power
MIL-W-8160	Wiring, Guided Missile, Installation of, General Specification for	Power
MIL-E-25499	Electrical Systems, Aircraft, Design and Installation of, General Specification for	Power
MIL-E-5007	Engine, Aircraft, Turbojet and Turbofan, General Specification for	Propulsion
MIL-E-5008	Engine, Aircraft, Turbojet, Model Specification for (Outline and Instructions for Preparation)	↓
MIL-E-5009	Engine, Aircraft, Turbojet and Turbofan, Tests for	↓
MIL-F-38363*	Fuel System, Aircraft, Design Performance, Installation, Testing, and Data Requirements, General Specifications for	↓
AFSC DH2-3	Propulsion and Power	Propulsion
MIL-HDBK-217	Reliability Stress and Failure Rate Data for Electronic Equipment	Reliability
MIL-STD-202	Test Methods and Electronic and Electrical Component Parts	↓
MIL-STD-453*	Inspection, Radiographic	↓
MIL-STD-750*	Test Methods for Semiconductor Devices	↓
MIL-STD-756	Reliability Prediction	↓
MIL-STD-757*	Reliability Evaluation from Demonstration Data	↓
MIL-STD-785*	Requirements for Reliability Program (for Systems and Equipment)	↓
MIL-STD-883*	Test Methods and Procedures for Microelectronics	↓
MIL-I-6868*	Inspection Process, Magnetic Particle	↓
MIL-Q-9858	Quality Program Requirements	Reliability

TABLE 6-2. (Sheet 6 of 6)

Number	Title	Category
MIL-R-22973*	Reliability Index Determination for Avionic Equipment Models, General Specification for	Reliability
MIL-I-45208*	Inspection System Requirements	Reliability
MIL-STD-882	System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for	Safety
MIL-S-23069	Safety Requirements, Minimum for Air Launched Guided Missiles	Safety
AFSC DH1-6	System Safety	Safety

*Possibly applicable.

7
MINIMUM COST PROCUREMENT

As part of this investigation, ARINC Research conferred with industry representatives concerning the best means of obtaining satisfactory quality and performance of drone/RPVs at the lowest possible price. Results of these discussions, together with explanatory background information, are presented in this section.

7.1 SYSTEM ACQUISITION PROCESS

The system acquisition process has been described in many ways, each reflecting contemporary policies and thinking as well as hard experience gained from problems encountered in past procurements. Currently, the design-to-cost philosophy is a major factor in system acquisition.

Regardless of the detail with which the acquisition cycle is characterized, only a few basic elements are involved. These are:

a. System Definition
b. Contractor Motivation
c. Contractor Control
d. Contractor Selection
e. Contractor Monitoring

The timeliness and judiciousness of the application of each of these elements determines the achieved mix of performance, reliability, cost, and initial operational capability (IOC) date. Unfortunately there is no magic formula by which these parameters can be analytically related. Experience becomes important here – the viewpoints of persons associated with past procurements of drones and related equipment. Some of these experiences were voiced in interviews conducted by ARINC Research during this study, and some of the comments have already been noted in other contexts (see Table 5-3, for example).

7.2 SYSTEM DEFINITION

Through the definition process, the buyer communicates to prospective contractors the scope of the system and technical approach that he understands will satisfy his operational requirement. Currently, this scope must include a cost target derived by the buyer in a preliminary process. This tradeoff is illustrated in simplified form in Figure 7-1. The tradeoff process is accomplished by application of cost estimating relationships (CERs) whenever cost and performance information for similar items is available.

From an overall DoD point of view, this step is becoming increasingly important. Decisions concerning this tradeoff have implications of extensive fund committments downstream during the operation and maintenance (O&M) phase. This cost impact cannot be dismissed as "someone else's problem" – the program manager is subject to review by DSARC for this aspect of his program.

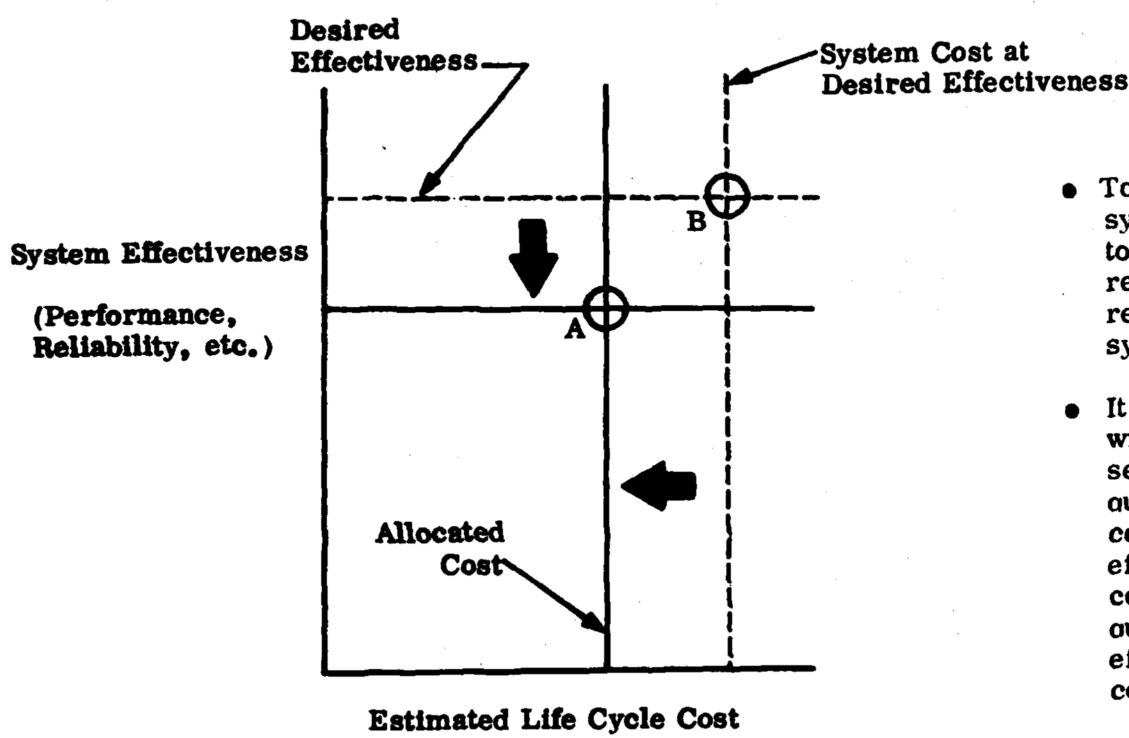
The definition process should be applied across the total system since contracting for one portion of a system without clear definition of the external interfaces and the ultimate overall functioning of the system has serious pitfalls.

7.3 CONTRACTOR MOTIVATION AND CONTROL

To produce the best product for the money, a contractor should have some form of motivation. Profit incentive is the most obvious motivator, but there are also other iorms. Along with profit must come the threat of penalty if profit and product quality are out-of-balance in favor of the contractor. To apply the controls necessary to balance profit and product quality, appropriate yardsticks for measuring progress must be built into the contract.

In the case of the engineering phase, the yardstick is the set of functional specifications and the measurement is the design review process and testing of prototypes to quasi-real environments and other conditions. Contractor motivation will suffer and unit cost may exceed estimates if the prototype tests are conducted with arbitrary and unrealistic environments and conditions.

If engineering development is accomplished by fixed-price contract, the contractor may be motivated to make system design decisions which are not to the overall benefit of the buyer.



- To achieve the best design-to-cost system, the Air Force is obligated to make the preliminary decisions regarding the basic tradeoff between required effectiveness and estimated system cost.
- It is likely that the cost associated with the desired performance (intersection B) may be too high. The question then is what alternate concept offers the smallest decrease in effectiveness at the allocated overall cost (intersection A). The ultimate question is whether the residual effectiveness is worthwhile or if the cost target should be adjusted.

Figure 7-1. System Cost Vs. Effectiveness Tradeoff

7.4 CONTRACTOR SELECTION

When the RFQ or RFP is issued, the contractor selection process starts. The selection process should take into account each potential contractor's experience with similar products. One contractor, operating according to commercial practices that have provided proven designs and equipment, may produce a better article for a lower cost than another contractor working to MIL-Q-9858A standards. Being qualified to MIL-Q-9858A is not in itself a guarantee of a quality product. For example a production line with rigid control built into its standard operations may lack proper controls as regards rework or nonstandard operations. The selection evaluation should treat such factors as risks against which company capabilities are carefully weighed.

7.5 CONTRACTOR MONITORING

Once a contract is let, the buyer's influence on cost versus performance and reliability resolves into monitoring the contractor according to the contract milestones, applicable specifications, and required deliverables. Motivation also plays a part during this period of monitoring. A posture of reasonableness on the buyer's part may extract more from a contractor than an inflexible stand.

7.6 PROGRAM-DECISION COST IMPACT

The point of the foregoing discussion is that the earlier decisions in a program generally have far-reaching impact on both the cost and performance of a system. This point is demonstrated in Table 7-1, which shows the potential cost consequences of failing to make proper decisions early in the program. (Figure 7-2 illustrates the life cycle phases.) Refer, for example, to the first entry in Table 7-1. In the Requirements Analysis phase of the system life cycle, the failure to make appropriate design-to-cost tradeoffs will impose a high cost penalty in several phases at the end of the life cycle.

In Table 7-1, the high (H), medium (M), and low (L) indices are relative to the total cost of the phase; that is, an H under Column 3 (Engineering Design) means a high cost impact relative to the total cost of engineering design. This impact may be small, however, compared to some other impact on, for example, production or O&M costs.

TABLE 7-1. COST IMPACT OF ACTIVITIES IN ACQUISITION CYCLE ON SUBSEQUENT EVENTS IN CYCLE (Sheet 1 of 4)

Decision or Activity	Cost Impact of Decision/Activity on Indicated Acquisition Cycle Event* (H = High, M = Medium, L = Low)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Requirements Analysis															
Make appropriate design-to-cost tradeoffs relative to estimated life cycle costs for various candidate approaches. Establish sensitivities of most significant trade factors.			L									H	H	H	
Determine whether interim capability is warranted and, if so, whether interim system has growth capability.			M											H	H
Identify potential quantities needed.			M									M			
Trade performance against other means of accomplishing job.			L									H		H	
Specify gross reliability and maintainability requirements for meaningful performance.			H									M			
Specify all support elements required to achieve desired performance.			M											M	
Derive reasonable turnaround-time requirements relative to mission scenario.			H									H			
State all assumptions regarding other resources and capabilities required for system operation (e.g., TACAN net, remote air base, etc.).			L												
Select a basic ILS approach that results in reasonable life cycle cost committment.			L											H	
Select some form of real-time in-flight monitoring appropriate to the system reliability goal, so that in-flight status can be assessed operationally if need arises.			L									L		H	
Adopt modular approach so that complete subsystem need not be flown each time.														M	
2. Preliminary Design															
Match performance goals to reasonable state-of-the-art.				M	M	H				M	M	H		H	
Identify needed existing equipment and its availability in proper time frame.															
Identify GFE/CFE boundaries to take best advantage of procurement advantages of each.												M			
3a. Engineering Design															
Create functional specification tree against a work breakdown structure.			L		M				M						
Require MIL specs (or design handbook sections) specifically only where required by study of:															
a. Manufacturer standards and procedures															
b. Environment (internal and external, thermal, EMI)															
Incorporate elapsed-time indicators (ETI's) in common and flight-critical components.														M	M
Incorporate design reviews at two or three points.			L				M		H	H				M	M
Allow contractor procedures, practices, and formats whenever practical and sound.			H	H				H				M			
Require an ILS plan.															

*Acquisition cycle events are defined in Figure 7-2.

TABLE 7-1. (Sheet 2 of 4)

Decision or Activity	Cost Impact of Decision/Activity on Indicated Acquisition Cycle Event* (H = High, M = Medium, L = Low)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3a. Engineering Design (Continued)															
Consider CPFF contract, which may cost slightly more but has significant impact on the LCC through sound system design tradeoff decisions.			M								M				
Select contractor with:															
a. Strong system engineering control															
b. Proven reliability and maintainability design capability.															
Review package for adequate production test specifications.														M	M
3b. Prototype Design															
Create system WBS, and control it to upper levels for visibility.															
Make sure objectives of prototype are clearly understood, and specify design and production practices consistent with objectives.															
Decide whether prototype should reflect production configuration or not.						H	H	L							
If so, make sure contractor has responsibility for showing how production AGE would operate and look relative to prototype AGE.									M	M	M			M	M
Determine which objectives require actual free-flight testing.					M										
Determine data collection needs of free-flight configuration.					M									M	M
Design test points to give proper access on-airplane and off-airplane.														H	H
Select contractor with effective prototyping capability.			M	M											
Require ILS plan.														M	M
Institute some form of configuration control (less than MIL-STD-482 may be acceptable) if prototype is likely to precede a production contract.						M			L	L	L				
4. Prototype Construction															
Permit contractor selection of specifications, procedures, and materials, but include data accession privilege for government.				M											
Use fixed-price contract only if total system is scoped in the statement of work. Don't be afraid to make downstream decisions requiring contract modifications, if life cycle cost benefits are at stake.														M	M
5. Prototype Testing															
Conduct all possible testing against objectives on the ground.					H										
Avoid formal range-control in favor of good instrumentation and data analysis.					M										
Contractually separate test support from prototype construction (use T&M for test support).															
6. Engineering Mod Production Configuration															
(No Comments)															

*Acquisition cycle events are defined in Figure 7-2.

TABLE 7-1. (Sheet 3 of 4)

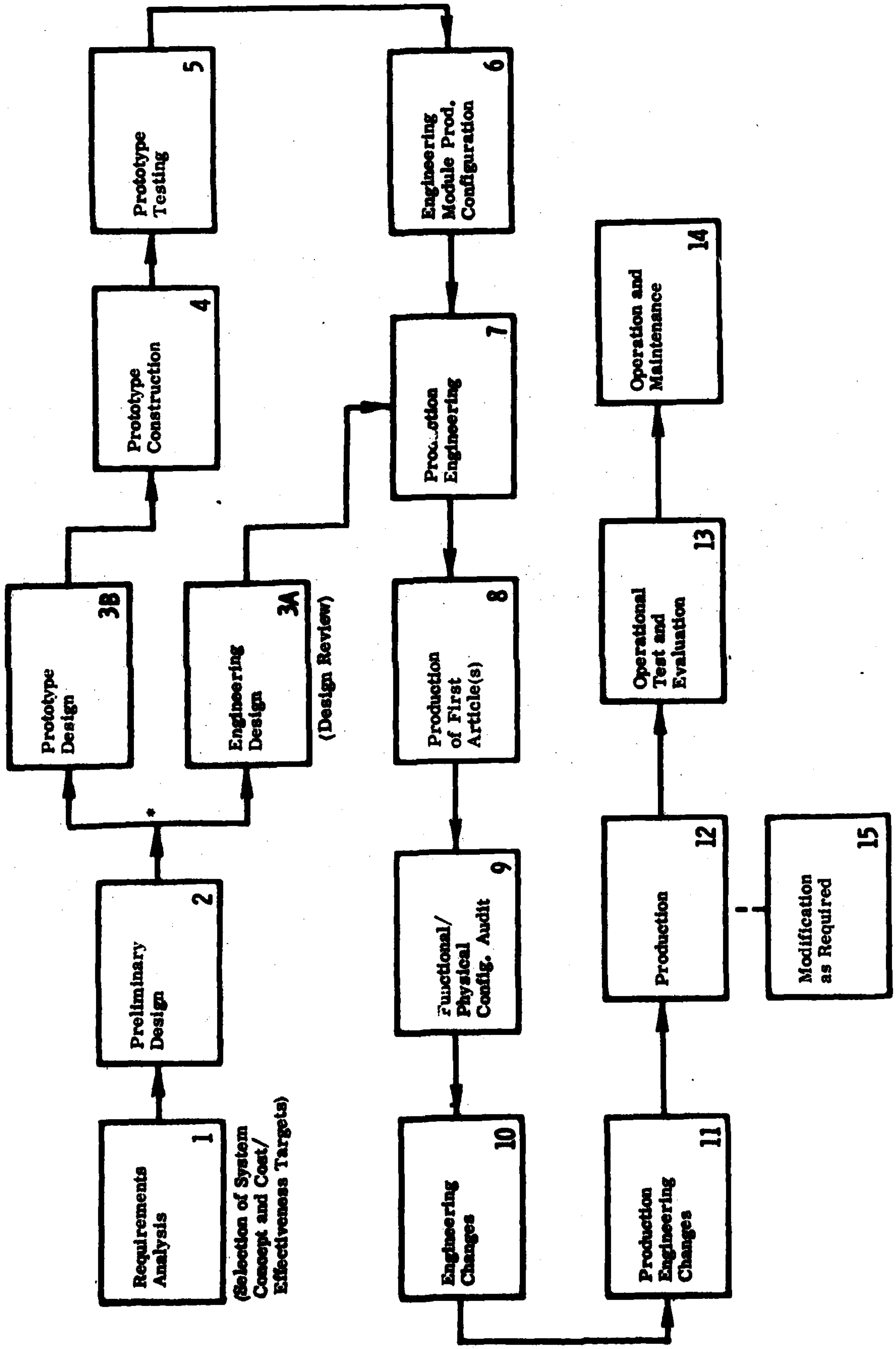
Decision or Activity	Cost Impact of Decision/Activity on Indicated Acquisition Cycle Event* (H = High, M = Medium, L = Low)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7. **Production Engineering**															
Ensure that all significant design and perform parameters are tested.															H
Design tooling to correspond to anticipated run potential.								(Impacts on follow-on prices)							
8. **Production (First Article)**															
Review contractor procurement plan to prevent total buy of time-life limited articles (particularly if fixed-price contract where motivation is to buy in largest possible quantity).														L	
9. **Functional/Physical Configuration Audit (First Article Testing)**															
Make test plan part of production contract RFQ.												M			
Require all contract end-items comprising operational system to be available concurrently for the function configuration audit (FCA).														M	
Substitute demonstration by analysis of similar units when life testing is impractical or unrealistic.									M						
Require final testing to be performed with "yellow" AGE against final-draft T.O.'s at contractor's facility.														M	
Incorporate T.O. validation into final step of in-plant testing.													H	L	M
Move system to flight test facility only after previous steps satisfactorily completed.									H	L			M		
Require DCAS/contractor QC monitoring and configuration control during complete first-article test.												M			M
Emphasize non-flight checkout of as many parameters as possible through a profile-simulation type of system setup (or other means).									M				M		
10. **Engineering Changes**															
Require proofing of engineering changes by in-plant demonstration, using similar set-up to original first-article test.														M	
11. **Production Engineering Changes**															
(No Comments)															
12. **Production**															
Require some form of verification of manufacturing process, such as one or more of the following (e.g., on random sampling basis throughout the production run): a. Configuration audit; b. Limited environment test; c. Check against drawing dimensions and specifications.														M	

*Acquisition cycle events are defined in Figure 7-2.

TABLE 7-1. (Sheet 4 of 4)

Decision or Activity	Cost Impact of Decision/Activity on Indicated Acquisition Cycle Event* (H = High, M = Medium, L = Low)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12. Production (Continued)															
Select manufacturer who has proven parts screening standard consistent with type of program; if selected contractor cannot demonstrate such a program, negotiate one into the contract before signing and then monitor it carefully.														M	
Same as above, but for internal parts control.															
13. OT&E															
(No Comments)															
14. Operation and Maintenance (O&M)															
Use contractor support for complex or state-of-the-art mission equipment.														M	
Use contractor as depot repair for nonstandard or peculiar equipment, including AGE.														M	
Operate and train from same written material. Accomplish this by using functional schematics and functional block diagrams in technical orders (T.O.'s).														M	

*Acquisition cycle events are defined in Figure 7-2.



*Prototype sequence may not be required.

Figure 7-2. Events in Acquisition Cycle Sequence

The purpose of Table 7-1 is to demonstrate where a cost-minimization program for drone/RPVs must begin: at the beginning. The proper decisions at the outset of an acquisition or modification program – to which a design handbook will make a major contribution – will be reflected in very substantial cost savings during the system life cycle.

8
EFFECT OF PROGRAM TYPE ON APPLICATION OF SPECIFICATIONS AND STANDARDS

The application of military specifications and standards to five different types of procurement program applicable to drone/RPVs is analyzed in this section. The program types are:

a. Competitive Prototype Development
b. Feasibility Demonstration
c. Class V Modification
d. Preproduction
e. Production

In performing the analysis, it was assumed that program cost is the primary consideration in designating which specifications are to apply. The requirements for technical orders, maintenance manuals, and other documentation needed to maintain the system in the field were not included in the analysis.

8.1 RATIONALE FOR APPLICATION OF SPECIFICATIONS AND STANDARDS

Specifications should be applied only as necessary and directly applicable, and even then only by reference to pertinent paragraph numbers. This will avoid the long-standing problem of automatic, expensive, and sometimes confusing inclusion of subsidiary specifications. All specifications thus applied should be continuously reviewed during the design cycle for applicability and necessity, with no design specification applied during the production phase that was not in force during the design phase.

Minimal use of specifications and standards should be made during prototype development or feasibility demonstration programs, to give the contractor the necessay flexibility at this creative stage. Greater use of specifications and standards is necessary for the preproduction, Class V modification, and production type programs to assure reliability and interchangeability during the large-scale production of systems.

Specifications and standards recommended for use in the five program types are listed in the context of the discussions of these programs in Section 8.2, and are summarized in Table 8-1. The specifications listed are those that will generally apply to all drone types. Certain drone types such as the expendable or long-endurance versions (e.g., Compass Cope) may require additional and more specialized documentation.

It must be emphasized that the specifications and standards listed are not, in most cases, to be applied in total, but only in terms of those selected paragraphs directly applicable to drone/RPV programs. The paragraphs that are directly applicable must be delineated when a design handbook is drafted.

8.2 DETAILED LISTING OF SPECIFICATIONS AND STANDARDS BY PROGRAM TYPE

For the five types of drone/RPV procurement, the following subsections summarize the prime task, deliverable items, required documentation, and recommended specifications and standards (see Table 5-1 or 5-2 for titles).

8.2.1 Competitive Prototype Development

Prime Task: Design, develop, and test a system to a set of mission requirements.

Deliverable Items: The prototype hardware, together with minimal documentation – engineering drawings and performance test results.

Documentation Required: Use of military specifications and standards should be restricted to those required to permit an evaluation of a proposed design and to assure that the tests performed upon competitive systems were made under equitable conditions.

Recommended Military Specifications and Standards:

a. Airframe – none
b. Propulsion – none
c. Power – MIL-STD-704
d. Environmental – MIL-STD-810
e. Avionics: MIL-STD-461, MIL-STD-462, MIL-E-5400 (modify para. 3.2.2.1.5, Vibration)

TABLE 8-1. APPLICATION OF SPECIFICATIONS BY DRONE/RPV PROGRAM TYPE (Sheet 1 of 2)

Specification	Program Type*	Specification	Program Type*
A. Airframe		E. Avionics (Cont)	
MIL-STD-1530	C, D, E	MIL-I-8500	C, E
MIL-A-8860	C, D, E	MIL-N-18307	
		MIL-E-25366	C, E
B. Propulsion			
MIL-E-5007	C, D, E	F. Maintenance	
MIL-E-5008	C, D, E	MIL-STD-470	C, D
MIL-E-5009	C, D, E	MIL-STD-471	C
		MIL-HDBK-472	C
C. Power			
MIL-STD-704	A, B, D, E	G. Reliability	
MIL-B-5087	D, E	MIL-HDBK-217	C, E
MIL-B-5088	C, D, E	MIL-STD-202	E
MIL-W-8160	C, D, E	MIL-STD-750	E
D. Environment		MIL-STD-756	C, E
MIL-STD-210	C, D, E	MIL-STD-757	C, E
MIL-STD-446	E	MIL-STD-785	C, D, E
MIL-STD-810	A, B, C, D, E	MIL-STD-883	C, E
MIL-T-5422	C, D, E	MIL-Q-9858	C, D, E
		MIL-I-45208	C, E
E. Avionics		H. Safety	
MIL-STD-188	E	MIL-STD-882	A, B, C, D, E
MIL-STD-461	A, C, E		
MIL-STD-462	A, C, E	I. Design	
MIL-E-5400	A, B, C, E	MIL-HDBK-275	E
MIL-I-6051	C, E	MIL-STD-143	C, D, E
MIL-E-8189	C, E	MIL-STD-242	

*A = competitive prototype development; B = feasibility demonstration; C = Class V modification; D = preproduction; E = production (all documents on page applicable).

TABLE 8-1. (Sheet 2 of 2)

Specification	Program Type*	Specification	Program Type*
I. Design (Cont)		I. Design (Cont)	
MIL-STD-454	A, B, C, D, E	MIL-D-11268	C, E
		MIL-M-38784	E
MIL-STD-480	C, E	AFP-300-7	E
MIL-STD-483	C, E		
MIL-STD-490	C, E		
MIL-STD-499	C, E		
MIL-STD-721	E	J. Manufacture	
MIL-STD-838	C, E	MIL-T-152	C, D, E
MIL-STD-881	C, E	MIL-STD-1516	C, D, E
MIL-D-1000	A, B, C, D, E	MIL-F-7179	C, D, E
		MIL-P-55110	C, D, E

*A = competitive prototype development; B = feasibility demonstration; C = Class V modification; D = preproduction; E = production (all documents on page applicable).

f. Maintainability – none
g. Reliability – none
h. Safety – MIL-STD-882 (partial)
i. Design: MIL-STD-454, MIL-D-1000 (category A, form 3)
j. Manufacturing method – none

8.2.2 Feasibility Demonstration

Prime Task: Develop a brassboard system to demonstrate the feasibility of a concept.

Deliverable Items: Results of the feasibility study, including all engineering drawings, test methods, and test results.

Documentation Required: Use of military specifications and standards should be limited to use as guides rather than being made mandatory in order to give the contractor maximum flexibility in his approach.

Recommended Military Specifications and Standards:

a. Airframe – none
b. Propulsion – none
c. Power – MIL-STD-704
d. Environmental – MIL-STD-810
e. Avionics – MIL-E-5400 (modify para. 3.2.2.1.5, Vibration)
f. Maintainability – none
g. Reliability – none
h. Safety – MIL-STD-882 (partial)
i. Design: MIL-STD-454, MIL-D-1000 (category A, form 3)
j. Manufacturing methods – none

8.2.3 Class V Modification

Prime Tasks: Modification of a drone/RPV or its components or equipment that will result in:

a. An improvement in military capability or operational performance;
b. Significant change in logistics or training requirements; or
c. A change in configuration to allow the vehicle to perform a permanently assigned mission other than the one for which it was originally procured.

Deliverable Items: All required hardware, a complete set of documentation sufficient to permit equipment modification on a large-scale production basis, and the design analyses and test results required to justify the design decisions.

Documentation Required: Because the modifications may involve many systems and be quite extensive, the use of military specifications and standards should be quite broad to help assure product reliability and interchangeability.

Recommended Military Specifications and Standards:

a. Airframe: MIL-STD-1530, MIL-A-8860
b. Propulsion: MIL-E-5007, MIL-E-5008, MIL-E-5009
c. Power: MIL-STD-704, MIL-B-5087, MIL-W-5088, MIL-W-8160
d. Environmental: MIL-STD-210, MIL-STD-810, MIL-T-5422
e. Avionics: MIL-STD-461, MIL-STD-462, MIL-E-5400 (modify para. 3.2.2.1.5, Vibration), MIL-I-6051, MIL-E-8189, MIL-I-8500, MIL-E-25366
d. Maintainability: MIL-STD-470, MIL-STD-471, MIL-HDBK-472
e. Reliability: MIL-HDBK-217, MIL-STD-756, MIL-STD-757, MIL-STD-785, MIL-STD-883, MIL-Q-9858, MIL-I-45208
f. Safety: MIL-STD-882
g. Design: MIL-STD-143, MIL-STD-454, MIL-STD-480, MIL-STD-483, MIL-STD-490, MIL-STD-499, MIL-STD-838, MIL-STD-881, MIL-D-1000, MIL-P-11268
h. Manufacturing methods: MIL-T-152, MIL-STD-1516, MIL-D-7179, MIL-D-55110

8.2.4 Preproduction

Prime Task: Design, develop, and manufacture a prototype system to a set of detailed requirements sufficient to permit large-scale production of the system at subsequent periods.

Deliverable Items: Prototype hardware plans, a complete set of documentation sufficiently detailed to permit production of systems on an assembly-line basis, and all required analyses.

Documentation Required: Should be limited to those necessary for the production of the system on an assembly-line basis. Such documentation as reliability, safety, and maintainability analyses, provided that they do not provide information directly required for system fabrication, should not be required for delivery, but should be available for inspection by Air Force personnel.

Recommended Military Specifications and Standards:

a. Airframe: MIL-STD-1530, MIL-A-8860
b. Propulsion: MIL-E-5007, MIL-E-5008, MIL-E-5009
c. Power: MIL-STD-704, MIL-B-5087, MIL-W-5088, MIL-W-8160
d. Environmental: MIL-STD-210, MIL-STD-810, MIL-T-5422
e. Avionics: MIL-STD-461, MIL-STD-462, MIL-E-5400 (modify para. 3.2.2.1.5, Vibration), MIL-I-6051, MIL-E-8189, MIL-E-25366
f. Maintainability: MIL-STD-470
g. Reliability: MIL-STD-785, MIL-Q-9858
h. Safety: MIL-STD-882
i. Design: MIL-STD-143, MIL-STD-454, MIL-D-1000
j. Manufacturing methods: MIL-T-152, MIL-STD-1516, MIL-F-7179, MIL-P-55110

8.2.5 Production

Prime Task: Design, develop and mass-produce systems to detailed requirements including military specifications and standards.

Deliverable Items: Production hardware plus a complete set of documentation sufficient to produce systems on a mass-production basis and maintain these systems in the field. All required analyses and tests results will also be delivered.

Documentation Required: Those documents necessary for production of the systems on a large-scale basis, maintaining these systems in the field, and presenting sufficient test and analytical results to assure that the systems will satisfy their operational requirements.

Recommended Military Specifications and Standards:

a. Airframe: MIL-STD-1530, MIL-A-8860
b. Propulsion: MIL-E-5007, MIL-E-5008, MIL-E-5009
c. Power: MIL-STD-704, MIL-B-5087, MIL-B-5088, MIL-W-8160
d. Environmental: MIL-STD-210, MIL-STD-446, MIL-STD-810, MIL-T-5422

e. Avionics: MIL-STD-188, MIL-STD-461, MIL-STD-462, MIL-E-5400 (modify para. 3.2.2.1.5, Vibration), MIL-I-8500, MIL-N-18307, MIL-E-25366

f. Maintainability: MIL-STD-470, MIL-STD-471, MIL-HDBK-472

g. Reliability: MIL-HDBK-217, MIL-STD-202, MIL-STD-750, MIL-STD-756, MIL-STD-757, MIL-STD-785, MIL-STD-883, MIL-Q-9858, MIL-I-45208

h. Safety: MIL-STD-882

i. Design: MIL-HDBK-275, MIL-STD-143, MIL-STD-242, MIL-STD-454, MIL-STD-480, MIL-STD-483, MIL-STD-490, MIL-STD-499, MIL-STD-721, MIL-STD-838, MIL-STD-881, MIL-D-1000, MIL-D-11268, MIL-M-38784

j. Manufacturing methods: MIL-T-152, MIL-STD-1516, MIL-F-7179, MIL-P-55110

9
AIR FORCE DRONE/RPV PROCUREMENT POLICIES

Most of the development effort concerning drone/RPV aircraft has involved modification of existing vehicles, either the target-drone BQM-34 series or manned aircraft. Much of the acquisition and/or modification work has been accomplished through the Big Safari Program, a quick-reaction capability (QRC)-type procurement characterized by the urgency of the requirement and short schedule involved. The resulting vehicles were low in cost and performed well in a combat environment. However, these vehicles were difficult to maintain and had poor reliability.

Contracts for the AQM-34 series vehicles associated with Big Safari avoided any program requirements for military specification or standard compliance. Many components and parts relating to the basic target drone vehicle were of commercial grade, but the manufacturer kept reasonably close to specification and standard compliance in his manufacturing, test, and inspection procedures through adherence to company doctrine. Documentation and data were generally poor or nonexistent. Later procurements, notably the AQM-34R and the AQM-91A drones, required compliance with military specifications, although some were design guides only. The AQM-34R design had contractual obligation in whole or part to more than 200 specifications and standards. Comments from industry representatives, however, criticized the Air Force as being less explicit than the other military services in defining procurement-related specifications. Subsequent requests for additional effort by the contractor often were found to be within the contractual requirements, but more than the contractor had understood as his obligation.

9.1 REGULATIONS AND DIRECTIVES

Armed Service Procurement Regulation (ASPR) 1-1201 states that items to be procured "...shall be described by reference to applicable specifications or by a description containing the necessary requirements." ASPR 1-1202 states that approved military specifications are mandatory for use by DoD in the procurement of supplies covered by such specifications.

ARINC Research is in no position to render a legal judgment concerning proper interpretation of the various regulations and directives. However, it is clear that the intent of the ASPR series is that military specifications and standards be applied to procurement where applicable. This requirement is qualified in the ASPR text: specifications for procurement are to state "only the actual minimum needs of the government". In particular, specifications need not be generated for items incident to research, development, test, or evaluation, but existing specifications must be used to the extent that they are applicable. Drone/RPV procurement, then, must be related to applicable military specifications and standards. If a design handbook is to direct the design of a drone/RPV, those portions of the handbook used as contractual requirements that have been extracted or modified from military specifications or standards should identify the source document to comply with the ASPRs. Certain specifications and standards are called out in the ASPRs with specific direction for inclusion in the procurement contract. These relate primarily to data submission and content, quality assurance, inspection procedures, and value engineering. Table 9-1 lists the specifications and standards called out in the ASPR series.

In addition to the ASPR, other pertinent directives have been promulgated which govern Air Force procurement policy as it relates to military specifications and standards. These Air Force, AFSC, and ASD regulations and manuals were screened in this investigation, and the direct references to military specifications and standards noted are listed in Table 9-1. The list should not be considered all-inclusive. In particular, references via intermediary documents were not traced. Generally, the regulations do not require direct contractual inclusion of a specification reference, but require conformance to the specification. Such conformance can be obtained by including pertinent portions of the referenced specification in a design handbook.

9.2 IMPACT OF CHANGES TO EXISTING SPECIFICATIONS

Air Force procurement policy, as it pertains to the application of military specifications and standards, should be little affected by changes to most of those documents. Adherence to the letter of specification requirements has never been fully realized. Changing technology, coupled with normal administrative inertia, create obsolescence in many of the technical specifications which then must be tailored by inputs to the detail specification for the procured item. Unfortunately, there is generally too little time or experience available to complete this task before a contract is let. Continuing negotiations are necessary between Air Force authorities

TABLE 9-1. MILITARY SPECIFICATIONS AND STANDARDS CALLED OUT IN ASPRs, AFRs, AND AFSCRs

Mil Spec/ Standard	Spec Type	Requiring Reference	Obligation
All Approved Specs		ASPR 1-1202	Mandatory use as applicable
MIL-STD-100	Drawings	AFR 65-3	As detailed
MIL-STD-129	Marking	ASPR 1-1204	Compliance required
MIL-STD-130	Marking	AFR 65-3	As detailed
MIL-STD-480	Configuration	AFR 65-3	As detailed
MIL-STD-481	Configuration	AFR 65-3	As detailed
MIL-STD-482	Configuration	AFR 65-3	Guidance
MIL-STD-490	Specification	AFR 65-3	As detailed
MIL-STD-881	WBS	ASPR 3-505	As detailed
MIL-STD-882	Safety	AFR 127-8	Selected portions
MIL-STD-891	Parts	AFSCR 800-13	Compliance required
MIL-D-1000	Drawing	ASPR 7-104.9	As detailed
MIL-Q-9858	Quality	AFR 74-1 ASPR 14-101	As detailed
MIL-M-19590	Radiation	ASPR 7-104.8	Compliance required
MIL-V-38352	Value Engrg.	ASPR 1-1707.1 ASPR 7-104.44	Mandatory - contractual clause (incentive contracts)
MIL-I-45209	Inspection	AFR 74-1 ASPR 14-101	As detailed*

*Use is mandatory in procurement of complex systems.

and the contractor to correct errors in the specification ar. ..move inappropriate requirements. In the case of drone/RPV procurements, Air Force representatives have usually been aware of the inappropriate specification areas relating to this special-type vehicle and have been able to delete some of the excessive requirements.

Changes to specification requirements expressed as sections of a drone/RPV design handbook may require some variation to Air Force procedure. Legal implications of contractual reference to a design handbook section, as opposed to a military specification paragraph with quoted modifications, must be explored through appropriate Air Force channels. The design handbook will be useful in either case.

APPENDIX A
INDIVIDUALS AND ORGANIZATIONS SURVEYED

Interviews were conducted with the following individuals and organizations to gather data and opinions concerning a drone/RPV design handbook:

TRA, San Diego, CA, 19 October, 6 November 1973

Mr. W. Evans, Reliability and Maintainability Engineering Manager

Mr. W. Immenshuh, Systems Integration Manager

Mr. W. Kearns, Manager, Design

Mr. R. Ogram, Systems Integration

Mr. K. Sargent, Systems Integration

Dr. C. B. Spangler, Technical Director

Mr. L. E. Anderson, Director, Quality Assurance

Mr. K. D. Hawkins, Quality Assurance

Mr. G. Smith, Quality Assurance

Northrop Corporation, Hawthorne, CA, 29 October 1973

Mr. Clyde Getz, Special Projects

Lear-Siegler, Inc., Santa Monica, CA, 7 November 1973

Dr. R. Elsner, Manager, Systems Engineering

Mr. J. Spagnoli, Marketing Manager

ASD, Dayton, Ohio, 12-15 November 1973

Col. E. Babcock, Deputy Director, Drone/RPV SPO

Lt. Col. T. Simon, Chief, Configuration Management Division (RWDC)

Lt. Col. R. Dudley, Test and Training

Lt. Col. J. Eibling, Program Control

Lt. Col. D. Newbold, RECCE (SIGINT) Systems

Maj. L. Lawrence, System Safety Officer

Maj. R. Strong, System Safety Engineer

Capt. B. Kozlen, Logistic Support

Capt. E. Parkinson, Quality Assurance

Mr. R. Waldmann, Engineering Reconnaissance Drones

Mr. D. Roetman, Engineering Reconnaissance Drones

ASD, Dayton, Ohio, 12-15 November 1973 (Continued)

Mr. D. Williams, Propulsion Engineering
Mr. R. Smith, Avionics Engineering
Mr. F. Mondini, Airframe Engineering
Mr. H. Shelley, Procurement and Production
Mr. R. Finegold, Systems Engineer STRIKE/EW System

WRAMA, Robins AFB, GA, 16 November 1973

Mr. D. Bush, Director MAT MGT (MMY)
Mr. W. Chapman

AFSC HQ, Andrews AFB, MD, 30 November 1973

Lt. Col. D. Hall, Drone Division
Maj. R. Wright

SAC HQ, Offutt AFB, NB, 27 November 1973

Maj. R. Skoneki (LGMA)
SMSGT C. Zink

TAC HQ, Langley AFB, VA, 28 November 1973

Lt. Col. W. Jackson, Drone Requirements (DRRD)
Capt. J. Duers

Teledyne CAE, Toledo, Ohio, 14 November 1973

Mr. F. Marsh, Vice President and Director, Harpoon Project
Mr. F. Pisanti, Deputy Director, Harpoon Project
Mr. W. Wagner, Manager R&M, Safety, Specifications
Mr. L. Mathews, Specifications
Mr. D. Lehnhardt, Project Engineer – Harpoon

E-Systems, Inc., Greenville, TX, 15 November 1973

Mr. J. Huddleston, Senior Project Engineer
Mr. C. Slagle, Senior Project Engineer
Mr. C. Phillips, Structures

Boeing, Seattle, WA, 19 November 1973

Mr. R. Plath, Program Manager, Compass Cope

Mr. R. Pitt, Deputy Program Manager, Compass Cope

Mr. D. O'Brien, Advanced Requirements and Design Concepts Manager

Northrop, Newbury Park, CA, 4 December 1973

Mr. O. Caperton, Manager, Aeronautical Tactical Engineering

Mr. R. Provart, Manager, Design Engineering

Mr. D. Margerum, Electronics

Mr. M. Bottoroff, Propulsion

Mr. K. Rogers, Air Vehicle

APPENDIX B
BIBLIOGRAPHY

a. Department of Defense

1. Index of Specifications and Standards, 1 July 1973

2. Directive 4100.35, Development of Integrated Logistic Support for Systems/Equipments

3. ASPR 1-109, 1-1201, 1-1202, 1-1204, 1-1707, 7-104, 7-302, 7-402, 7-901, 9-503, 14-101, 14-303, 14-304, AF Sup 3-505

4. AFSC Design Handbooks, Series 1-0, 2-0, 3-0, 4-0

b. Air Force

1. AF Regulations 65-3, 66-44, 67-4, 70-1, 73-1, 74-1, 81-10, 81-10 AFSC Sup 1, 127-8, 310-1, 310-3, 320-1, 320-1 AFSC Sup 1

2. AFSC Regulations 57-3, 57-4, 800-1, 2, 5, 7, 9, 10, 11, 12, 13, 16, 18

3. AFSC Manual 81-1, 18 Oct. 1971

4. AFP-800-7, Integrated Logistic Support Implementation Guide for DoD Systems and Equipment

5. Compass Bright Expansion Capability, 17 August 1973

c. ARINC Research Corp.

1. The User-Technologist-Industrial Approach to Electronic Equipment Specifications and Procurement, Publ. 1113-01-2-1257, July 1973

2. Ground Support Equipment Acquisition Manager's Handbook, Publ. 971-01-1-1169, April 1972

d. Teledyne-Ryan

1. Environmental Design Requirements for SPA Model 147, Publ. 14759-100, Jan. 1969

2. General Environmental Test Methods for Model 147 Vehicle Components and Associated Support Equipment, Publ. 14775-1, 12 March 1971

3. 147SD Specification 14759-629D (SECRET), July 1972

4. 147TF Specification 14759-772F (SECRET), Aug. 1973

5. 147S Specification 14759-175D (SECRET), Nov. 1968

6. 147TE Specification 14759-760, Rev. B (SECRET), Aug. 1971

e. Lear-Seigler

1. System Specification for Avionics Update (U), SECRET, Publ. SR45000-01

f. Northrop

1. Project Data Manual (ANS Project), 27 Nov. 1964

2. ANS Project Integrity Manual, 25 June 1964

3. USAF Multi-Mission RPV Systems Study, Publ. ASD/XR-72-12; ASD/XR-72-11

g. Philco-Ford

1. Reliability and Maintainability Design Criteria for AFSCF Equipment, Publ. WDL-TR4832A, 24 April 1972

APPENDIX C
QUESTIONNAIRE USED IN DRONE/RPV DESIGN HANDBOOK STUDY

ARINC QUESTIONNAIRE

DESIGN HANDBOOK STUDY FOR DRONE/RPV

1. List specifications and standards presently being used by your organization to build Drone/RPV Systems and identify the reason for use as shown below:
   - (a) Full compliance required by contract
   - (b) Modified compliance required by contract
   - (c) Called out as design goals
   - (d) Company requirement only
   - (e) Trapped by implication
2. What is your opinion as to the applicability and effectiveness of the above-mentioned documentation?
3. Is there any specific historical data that helped you in forming the above opinions?
4. List specifications and standards which you think should be included in a design handbook for Drone/RPV. Indicate those documents (a) requiring modification for this purpose, (b) to be used only as "design goals", and (c) to be implemented fully as design requirement, by marking (a), (b) or (c) after the entry. (If (a), describe modification)
5. What do you believe to be the best means of obtaining quality and performance at the lowest possible price?
6. What is your opinion regarding the application of specifications and standards, and other contractual requirements, at the following procurement levels?
   - (a) Competitive prototype development
   - (b) Feasibility demonstration
   - (c) Class V modification
   - (d) Preproduction
   - (e) Production

7. Discuss Air Force (or other DoD agency) procurement policy with respect to technical aspects of your production contracts and indicate to what extent they reference existing standards and specifications.

8. What are the effects of mission requirements on the use of specifications and standards? Is the imposition of specifications and standards helpful in meeting mission requirements? Do you feel that the specifications in current procurement documents are directly applicable to mission requirements?

9. What is your opinion regarding the need for a design handbook?

10. Would your company be willing to use "warranties" in lieu of performance and reliability demonstrations?